GOA UNIVERSITY
Taleigao Plateau, Goa 403 206

R E V I S E D M I N U T E S

of the 11th Meeting of the

X ACADEMIC COUNCIL

Day & Date

Friday, 9th December, 2022

Time

10.00 a.m.

Conference Hall
Administrative Block
Goa University

D 3	**BOARDS OF STUDIES**
D 3.1	**Minutes of the Board of Studies in Botany meeting held on 10.10.2022.** The Academic Council approved the minutes of the Board of Studies in Botany meeting held on 10.10.2022 recommending M.Sc. Botany syllabus for Semester III and IV with the following suggestions: 1. Learning outcomes for the Courses to be clearly mentioned. 2. The Course 'Ecotourism' to be reviewed. 3. Pre-requisite for practical Courses to be revised. 4. Research Methodology syllabus for Ph.D. course work was approved. 5. Uniform format to be followed for Reference/Readings indicating the year of publication, name of the publisher etc. **(Action: Assistant Registrar Academic – PG)**
D 3.2	**Minutes of the Board of Studies in History (PG) meeting held on 27.10.2022.** The Academic Council did not approve the minutes of the Board of Studies in History (PG) meeting held on 27.10.2022. The Chairperson was requested to incorporate the following suggestions: 1. The entire content of the syllabus to be shown in a proper standard format having details of Number of hours, Credits, Prerequisites, Course objectives, Pedagogy, References/Readings etc. and to be listed in the alphabetical order. 2. Dissertation for the Programme under Semester IV to be included. After inclusion of the suggested changes, the Chairperson, Board of Studies was requested to present the same before the Standing Committee of the Academic Council for approval. **(Action: Assistant Registrar Academic – PG)**
D 3.9	**Minutes of the Board of Studies in Indian Classical Music meeting held on 29.09.2022.** The Academic Council did not approve the minutes of the Board of Studies in Indian Classical Music meeting held on 29.09.2022. The Chairperson was requested to format the content of the syllabus in the standard format indicting details of Number of Hours, Credits, Prerequisites, Course Objectives, Pedagogy, and list the References/Readings in the alphabetical order. After inclusion of the suggested changes, the Chairperson, Board of Studies was requested to present the same before the Standing Committee of the Academic Council for approval. **(Action: Assistant Registrar Academic – PG)**
D 3.10	**Minutes of the Board of Studies in Commerce (PG) meeting held on 02.06.2022.** The Academic Council approved the minutes of the Board of Studies in Commerce (PG) meeting held on 02.06.2022 with the following suggestions: 1. The entire content of the syllabus to be shown in a proper standard format having details of Number of hours, Credits, Prerequisites, Course objectives, Learning outcomes, Pedagogy, References/Readings, year of publication etc. and

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GOA UNIVERSITY
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F I N A L A G E N D A

For the 11th Meeting of the

X ACADEMIC COUNCIL

Day & Date

Friday, 9th December, 2022

Time

10.00 a.m.

Venue
Conference Hall
Administrative Block
Goa University

	D 7.2 To consider the Proposal to review the fee structure for the Ph.D. Programmes offered at the Goa University Campus and Affiliated General Education Colleges	Circular No GU/Acad-PG/Tuition Fees/2022-23/472 dated 19.10.2022 issued
	D 7.3 Proposal of Board of Studies in Konkani to have a separate Under-Graduate and Post-Graduate Board of Studies in Konkani.	Decision conveyed to the BoS Chairperson vide email dated 07.10.2022. Committee set up under the Chairpersonship of Prof. Savita Kerkar to review the Ordinance OA-14 relating to Board of Studies in various subjects vide Order No GU/Acad-PG/Ord.OA-14/2022/350 dated 25/8/2022.
	D 7.4 To consider the Proposal for conducting a Common Entrance Test for admissions to General Education UG Programmes offered by the Goa University and the Affiliated Colleges.	Decision conveyed vide letter No GU/Acad-PG/2022/475 dated 20.10.2022 to Goa Board of Secondary & Higher Secondary Education.
	D 10 ANY OTHER BUSINESS [A.O.B]	
	D 10.1 Status relating to Special Ordinance OS-1 relating to the conduct of Academic Programmes during the COVID-19 Pandemic.	The Ordinance OS-1 has been repealed vide Notification No 2/701/2022-Legal (VolXXV)/734 dated 4th November, 2022.
	D 10.2 Letter received from Govt. College, Quepem requesting for clarification regarding Eligibility of students under Ordinance OC-66 with respect to clause OC-66.5.2 (g).	Noted
	D 10.3 Constitution of Board of Evaluation – Nomination of the member of the Academic Council.	Action being initiated
	D 10.4 Appointment of Discipline Committee/Unfair Means Inquiry Committee.	Order issued to all the members vide Order No GU/EXAM/UMIC/42/2022/149 dated 17/10/2022.
	D 10.5 To consider the proposed dates for the meetings of the Academic Council.	Noted. (Back to Index)
D 3	**BOARDS OF STUDIES**	
D 3.1	**Minutes of the Board of Studies in Botany meeting held on 10.10.2022.** **Part A** (i) Recommendations regarding courses of study in the subject or group of subjects at the undergraduate level**:** **NIL** (ii) Recommendations regarding courses of study in the subject or group of subjects at the post-graduate level: **1. Revision of the Course Structure and the syllabus of Semester III & IV. (Annexure I Refer page No.22)** **2. Revision of the syllabus of Ph.D. Research Methodology (Annexure II Refer page No. 63)**	

	Part B (i) Scheme of examinations at the under-graduate level: Nil (ii) Panel of examiners for different examinations at the under-graduate level: **Nil** (iii) Scheme of examinations at the post-graduate level: **Nil** (iv) Panels of Examiners for different examinations at post-graduate level: **Nil** **Part C** (i) Recommendations regarding preparation and publication of selection of reading material in any subject or group of subject or group of subjects and names of persons recommended for appointment to make the selection.: **Nil** **Part D** (i) Recommendations regarding general academic requirements in the Departments of University or affiliated Colleges: NIL **Part E** (i) Recommendations of text books for the courses of study at the under-graduate Level: **NIL** (ii) Recommendations of text books for the courses of study at Post-Graduate Level: **Yes. Updated the reference list.** **Part F** (i) The important points/recommendations of BoS that require consideration/approval of Academic Council (points to be highlighted) as mentioned below**.** **1. Revised structure and Syllabus of M.Sc. Botany for the Semester III & IV.** **2. Revised syllabus of Ph.D. Research Methodology.** The declaration by the Chairman, that the minutes were approved by all BoS members. Date: 21.10.2022 Sd/- Place: Goa University Signature of the Chairman **Part G**. The Remarks of the Dean of the Faculty i) The minutes are in order. ii) The minutes may be placed before the Academic Council with remarks if any. iii) May be recommended for approval of Academic Council. iv) Special remarks if any. Date: 27.10.2022 Sd/- Place: Goa University Signature of the Dean **(Back to Index)**
D 3.2	**Minutes of the Board of Studies in History (PG) Meeting held on 27.10.2022.** **Part A**. i. Recommendations regarding courses of study in the subject or group of subjects at the undergraduate level: NIL

D 3.1 Minutes of the Board of Studies in Botany meeting held on 10.10.2022.

Annexure I

School of Biological Sciences and Biotechnology
M.Sc. Botany Programme (Code: 1453)
(Choice Based Credit System - 80 Credits)

Course Structure

Course Code	Course Title	Credits
SEMESTER I		
Core Courses		
BOTC-401	Algae, Bryophyta, Pteridophyta and Gymnosperms	3
BOPC-401	Lab in Algae, Bryophyta, Pteridophyta and Gymnosperms	1
BOTC-402	Systematics of Angiosperms	3
BOPC-402	Lab in Systematics of Angiosperms	1
BOTC-403	Internal Morphology and Developmental Biology of Angiosperms.	3
BOPC-403	Lab in Internal Morphology and Developmental Biology of Angiosperms	1
BOTC-404	Plant Physiology	3
BOPC-404	Lab in Plant Physiology	1
Discipline Specific Electives (Any 4 credits)		
BOTE-401	Plant Biotechnology	3
BOPE-401	Lab in Plant Biotechnology	1
BOTE-402	Plant Biochemistry	3
BOPE-402	Lab in Plant Biochemistry	1
SEMESTER II		
Core Courses		
BOTC-405	Microbiology and Plant Pathology	3
BOPC-405	Lab in Microbiology and Plant Pathology	1
BOTC-406	Cytogenetics and Plant Breeding	3
BOPC-406	Lab in Cytogenetics and Plant Breeding	1
BOTC-407	Plant Molecular Biology	3
BOTC-408	Plant Genetic Engineering	3
BOPC-409	Lab in Plant Molecular Biology and Genetic Engineering	2
Discipline Specific Electives (Any 4 credits)		
BOTE-403	Modern Concepts in Plant Ecology	3
BOPE-403	Lab in Modern Concepts in Plant Ecology	1
BOTE-404	Mycorrhizal Biotechnology	2
BOPE-404	Lab in Mycorrhizal Biotechnology	1
BOTE-405	Introduction to Paleoflora	1
SEMESTER III		
Discipline Specific Generic Courses (Any 12 credits)		
BOTG-501	Introduction to Omics	3

BOTG-502	Plant-Animal Interactions	4
BOTG-503	Ecotourism	2
BOPG-503	Lab in Ecotourism	2
BOTG-504	Mushroom Biotechnology	1
BOPG-504	Lab in Mushroom biotechnology	1
BOTG-505	Marine Phytoplanktons	1
BOTG-506	Oenology (Wine Science and Technology)	1
BOPG-506	Lab in Oenology (Wine Science and Technology)	1
BOTG-507	Ethnobotany	2
Research Specific Elective Courses (Any 8 credits)		
BOTR-501	Plant Histochemistry	3
BOPR-501	Lab in Plant Histochemistry	1
BOTR-502	Seed Science and Technology	3
BOPR-502	Lab in Seed Science and technology	1
BOTR-503	Genome Informatics	3
BOPR-503	Lab in Genome Informatics	1
SEMESTER IV		
Research Specific Elective Courses (Any 4 credits)		
BOTR-504	Research Methodology, Techniques and Instrumentation	4
BOTR-505	Applied Phycology: Utilization and Management	4
BOPD	**Dissertation**	16

SWAYAM COURSES **Recommended for Post Graduate level**		
Course Code	**Title of the Course**	**Credit Equivalent**
	Discipline Specific Generic Electives	
noc20-bt38	Wildlife Ecology	3
noc20-bt41	Nanotechnology in Agriculture	2
noc20-ag05	Organic Farming for Sustainable Agricultural Production	2
noc20-bt29	Biomedical Nanotechnology	1
cec20-ag14	Functional Food and Nutraceuticals	4

	Research Specific Electives	
cec20-ge29	Academic writing	4
cec20-bt23	Biostatistics and Mathematical Biology	3
noc20-bt31	Experimental Biotechnology	3
cec20-bt24	Biomass Characterization	4

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SEMESTER III

Discipline Specific Generic Courses

Programme: M. Sc (Botany)
Course Code: BOTG-501
Title of the Course: Introduction to Omics
Number of Credits: 3
Effective from AY: 2022-23

Prerequisites for the course:	Should have basic knowledge of structure of genome, genes, structure of proteins and metabolism.	
Objective(s):	This course will make students familiarize with terminology, underlying principals and methodology in genomics, transcriptomics, proteomics and metabolomics. The paper includes protein dynamics, protein trafficking machinery and autophagy for protein turnover. The role of protein networks in mediating cellular responses and transmitting signals will be highlighted.	
Content:	1. **Genomics:** Classical genomics, Mendelian Genetics, Forward/Reverse Genetics, Linking Genotype and phenotypes, use and screening of mutants. Large Scale Genomic Sequencing: Platforms for Next Generation Sequencing (NGS), Second and third generation sequencing, whole genome sequencing, targeted sequencing, Chromatin Immunoprecipitation (ChIP) sequencing, Applications of Genome sequencing and analysis. Epigenomics: Epigenome and Epigenetic regulation in Plants, Epigenetic modifications and their implications, DNA methylation, Histone modification, Plant Mediator Complex, Epigenomic analysis. 2. **Transcriptomics:** Differential expression, Alternate splicing, RNA sequencing and analysis, cDNA microarray analysis, ENCODE (Encyclopedia of DNA elements) project. 3. **Proteomics:** Protein structure and function, amino acids, peptides, protein synthesis. Post translational modifications of proteins: Glycosylation, Phosphorylation, Acetylation, Methylation, Ubiquitinylation, Sumolyation, Identification of post-translational modification in proteins, protein phosphorylation assay. Protein transport and Secretion, Protein targeting and trafficking, ER Golgi dynamics in protein sorting,	**11 hours** **4 hours** **20 hours**

	dynamics of membrane bound protein, mechanism of protein secretion. Protein degradation: Ubiquitin-proteosome pathway, Lysosomal Proteolysis, role of autophagy and vesicular trafficking in degradation of protein. Essentials of Protein-protein interaction: Protein interacting motifs, multi-protein complex, application of protein interactions, databases and tools to study Protein interactome. Protein Networks in Plant signalling: Introduction to plant signalling, types of membrane receptors (Membrane receptors, intracellular and extracellular receptors, G-protein coupled receptors, ion channels, Pattern recognition receptors), components of cell signalling (secondary messengers, sensors and effectors, Two-component system, signal perception), Types of signalling pathways, reversible phosphorylation and dephosphorylation, role of plant signalling in development and immunity, Proteomic analysis, Techniques in proteomics and analysis: 2D electrophoresis, MS-ESI, MALDI-TOF, Protein Microarray. 4. **Metabolomics:** Overview of Metabolites, basics of metabolic pathways, errors of metabolism, sample preparation, extraction, derivatization, Targeted v/s untargeted metabolomics, Identification of molecular features and metabolites, structural confirmation, application of metabolomics in diagnosis. 5. **Metagenomics and Metatranscriptomics:** Introduction and overview, Sample harvesting, preparation, RNA extraction, sequencing strategies and data analysis.	**7 hours** **3 hours**
Pedagogy:	Lectures/Tutorials/Seminars/Assignments	
References/ Readings:	**António, C.** (2018) Plant Metabolomics- Methods and Protocols, Humana press, Hertfordshire, UK. **Cooper, G.M.** (2000) The Cell: A Molecular Approach. 2nd edition. Sunderland (MA): Sinauer Associates, UK. **Karp, G.** (2009) Cell and molecular biology: Concepts and experiments, 7th edition. John Wiley & Sons, USA. **Kramer, I. M.** (2015) Signal Transduction, 3rd edition, University of Bordeaux, Talence, France. **Nelson, D. L., Cox, M. M., and Lehninger, A. L.** (2013) Principles of biochemistry (p. 245), Freeman, New York. **Primrose, S. B. and Twyman, R. M.** (2006) Principles of gene manipulation and genomics, Blackwell Publishing, Australia. **Reece, R. J.** (2004) Analysis of genes and genomes. John Wiley & Sons Ltd.	

	Saraswathy, N. and Ramalingam, P. (2011) Concepts and Techniques in Genomics and Proteomics. Biohealthcare Publishing (Oxford) Limited, New York. **Segev, N.** (2009) Trafficking Inside Cells, Springer science Business media, USA. **Sessa, G.** (2012) Molecular Plant Immunity. John Wiley & Sons, Inc, Isarel. **Voet, D., Voet, J. G. and Pratt, C. W.** (2016) Fundamentals of biochemistry: life at the molecular level. John Wiley & Sons, USA. **Walker, J. M. and Rapley, R.** (2008) Molecular Biomethods Handbook, Hertfordshire, UK. **Wilson, K. and Walker, J.** (2010) Principles and techniques of biochemistry and molecular biology, 7th edition. Cambridge University Press, UK.	
Learning Outcomes:	Students will get familiar with principles and applications in Genomics, Transcriptomics, Proteomics, Metabolomics, Metagenomics and Metatranscriptomics. They will be able to apply basic concepts in research.	

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Programme: M. Sc (Botany)

Course Code: BOTG-502

Title of the Course: Plant-Animal Interactions.

Number of Credits: 4

Effective from AY: 2022-23

Prerequisites for the course:	Should have basic degree in biology.	
Objective(s):	• This course bridges the gap between various branches of biological sciences. • Application in the areas of biodiversity, conservation, pollination, crop productivity, biological control, bioprospecting, etc.	
Content:	1. **Diversity and Plant-Animal interactions:** Mutualism, Antagonism, Commensalism, Competition, Multi-trophic level interactions; Species interactions and the evolution of biodiversity; Co-evolution and co-speciation of plants and animals; adaptive radiation; evolutionary history of interactions and evidences in the geological past; principle of allocation. 2. **Pollination Biology:** Importance of cross pollination. Evolutionary origin and early diversification of animal pollination; Special differentiation associated with pollinator attraction – advertisement and reward (pollen, nectar, elaiophores, resin glands, osmophores, optical displays and visual clues). Floral adaptation to different pollinators; insect visitors (Hymenoptera, Diptera, Coleoptera, Lepidoptera,	**7 Hours** **10 Hours**

	Thysanoptera), birds, bats, non-flying animals. Sapromyiophily, brood-site pollination; fig-wasp interaction and pollination. Pollination Biology and gene flow: Foraging theory, foraging strategies and time-niche strategies. 3. **Fruits, Seeds and Dispersal agents:** Plant adaptations – Fruit chemistry (chemical compartmentalization – pulp and seed, nutritional aspect of pulp, palatability inhibitors and toxins). Seed coat, seed toxins. Phenology; signals, fruit size and fruit production. Dispersers: range of seed dispersers, seed shadow, frugivores as foragers: seed predators. Animal adaptations – External and internal morphology, digestive physiology, behaviour. Factors limiting reciprocal plant and animal specializations. 4. **Herbivores and green plants:** Nutritional requirements of insects, seasonal and temporal distribution of nutrients in plant parts; Co-evolutionary arms race – plant defence and animal response; plant defence against herbivores – physical, chemical and 'third party' defences; animal responses – behaviour, detoxification, conjugation, target-site insensitivity, excretion. Herbivory v/s plant fitness. Herbivore efficiency and ecosystem dynamics, Effect of herbivores on plant communities – The Janzen-Connell hypothesis. Effect of herbivores on plant communities. Hormonal interaction between plants and animals; hormone signalling in trophic interactions; animal pheromones and defense substances. 5. **Ant-plant interactions:** The origin and early evolution. Ant-plant symbioses – mutualism and non-mutualism (herbivores, harvesting ants, granivores and leaf-cutting). Ants as primary and secondary seed dispersers; pollination by ants; direct and indirect association with plants; ant-fed plants and ant gardens; canopy ants; effects of harvesters on vegetation. Temporal and spatial variation in ant-plant interactions. Fungus growers. 6. **Carnivorous plants:** Mechanisms of interaction between carnivorous plants and animals, trap mechanisms; nutritional benefits of carnivory; cost-benefit analysis. Evolutionary pathways to carnivory. 7. **Plant communities as animal habitats:** Adaptations, ecological segregation within and between habitats; mechanisms of habitat selection, habitat selection theory, characteristics of plant resources and animal population dynamics, effects of plants on animal spacing and aggression. Animal diversity in relation to plant resource characteristics. Impact of invasive plants on native plant-animal interactions. Plant-animal interactions in agricultural ecosystems. Conservation aspects of plant-animal interactions. 8. **Climate change and breakdown of plant-animal interaction:** Impact on community, diversity, productivity, and livelihood.	**8 Hours** **13 Hours** **7 Hours** **4 Hours** **8 Hours**

		3 Hours
Pedagogy:	Lectures/ Tutorials/Assignments/Field observations	
References/ Readings:	**Abrahamson, W.G.** (ed.). (1989). Plant-animal interactions. McGraw-Hill Book Company, NY. **Burslem, D., M. Pinard and S. Hartley. (**2005). Biotic Interactions in the Tropics: Their Role in the Maintenance of Species Diversity. Cambridge University Press. **Crawley, M.J.** (1986). Plant Ecology. Blackwell Scientific Publications. **Del-Claro, K. and Torezan-Silingardi, H. M.** (2021). Plant-animal interactions. Springer International Publishing, Switzerland. **Endress, P.K. (**1994). Diversity and Evolutionary biology of tropical flowers. Cambridge University Press. **Harborne, J.B. (**1988). Introduction to ecological biochemistry. Academic Press. **Herrera, Carlos M. and Olle Pellmyr** (eds.). (2002). Plant Animal Interactions: An Evolutionary Approach. Blackwell Science. **Holldobler, B. and Wilson, E.O. (**1990). The Ants. Springer-Verlag. **Lloyd, D.G. and Barret, S.C.H. (**1996). Floral Biology: studies on Floral evolution in Animal pollinated plants. Chapman and Hall. **Price, P.W., T.M. Lewinsohn, G.W. Fernandes and W.W. Benson. (**1991). Plant-Animal Interactions: Evolutionary Ecology in Tropical and Temperate Regions. A Wiley-Interscience publication **Proctor, M., Yeo, P. and Lack, A.** (1996). The Natural History of Pollination. Harper Collins Publishers. **Richards, A.J. (**1986). Plant Breeding systems. George Allen and Unwin, London. **Schaefer, M.H. and G.D. Ruxton.** (2011). Plant-Animal Communication. Oxford University Press. **Seckbach, J. and Z. Dubinsky.** (2010). All Flesh Is Grass: Plant-Animal Interrelationships. Springer Science and Business Media. **Simberloff, D.** (2022). Concise, comprehensive reviews of how invasive plants interact with plants, animals, and microbes. Biological invasions, Springer. **Smith, R.L.** (1990). Ecology and field biology. Harper and Row Publishers, New York. **Waser, N.M. and J. Ollerton.** (2006). Plant-Pollinator Interactions: From Specialization to Generalization. University of Chicago Press. **Whitmore, T.C.** (1990). An introduction to tropical rain forests. Clarendon Press, Oxford.	

	Willmer, Pat. (2011). Pollination and Floral Ecology. Princeton University Press.	
Learning Outcomes:	1. Would have understood intricate evolutionary relationships between plants and animals including their interdependence. 2. Should have learnt the role of herbivory in phytochemical evolution and its importance in plant-based drugs. 3. Would have understood the importance of multicultural practices in the control of pests, organic farming, and reduction of chemical pesticides. 4. Able to appreciate the ecosystem services through these plant-animal interactions. 5. Understand the effect of climate change on these interactions, conservation, and survival of human species.	

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Programme: M. Sc (Botany)
Course Code: BOTG-503
Title of the Course: Ecotourism.
Number of Credits: 2
Effective from AY: 2022-23

Prerequisites for the course:	Basic knowledge in General Biology.	
Objective(s):	• To create self-employment opportunities. • To create awareness towards the conservation of natural resources. • To help the students assess various ecotourism programmes.	
Content:	1. **Eco-tourism:** Definition, concept, introduction, history, relevance and scope. 2. **Key Principles and Characteristics of Ecotourism**: Nature area focus, interpretation, environmental sustainability practices, contribution to conservation, benefiting local communities, cultural respect, customer satisfaction, responsible marketing. 3. **Components of Ecotourism:** Travel, tourism industry, biodiversity, local people, cultural diversity, resources, environmental awareness, interpretation, stake holders, capacity building in ecotourism. 4. **Eco Tourism Terms**: Adventure tourism, certification, commercialization chain, cultural tourism, canopy walkway, conservation enterprises, ecosystem, ecotourism activities, ecotourism product, ecotourism resources, ecotourism services, endemism, ecolabelling, ecotourism "lite", Geotourism, greenwashing, stakeholders, sustainable development, sustainable tourism, leakages. 5. **Ecotourism resources in India and Goa**: Major ecosystems, vegetation types, biodiversity and tourism areas in Goa.	**1 hour** **2 hours** **2 hours** **5 hours**

	Festivals and events, entertainment overview, culture, famous destinations, sightseeing, historical monuments, museums, temples, national parks and wildlife sanctuaries, hill stations, waterfalls, rivers, lakes, beaches, islands, mangroves, backwaters, wildlife watching and bird watching sites, rural handicrafts, tribal medicines, archeological sites, adventure sports, sacred groves, mountains, etc. 6. **Forms of Ecotourism in India and Goa**: Eco regions, Eco places, Western Ghats of Goa, Waterfalls in Goa and India, Eco travel: do's and don'ts, Eco trips. Potentials of ecotourism in Goa. Community based ecotourism. 7. **Ecotourism Planning**: Background, objectives, strategy, design of activities, target groups, opportunities, capacity building, threats, expectations positive and negative impacts, strength and weakness, benefits and beneficiaries, stakeholders, linkages, economics, ecotourism auditing. Problems with ecotourism. Carrying capacity of ecotourism. Ecotourism facilities – Green report card. Ecotourism management – issues. 8. **Ecotourism and livelihood security:** Community, biodiversity conservation and development – Eco-development committees.	**8 hours** **5 hours** **4 hours** **3 hours**
Pedagogy:	Lectures/Tutorials/Videos/Films/Group Discussion/ Expert Lectures/Assignments.	
References/ Readings:	**Batta, A.** (2000). Tourism and environment. Indus Publishing Co., New Delhi. **Bhattacharya, A.K.** (2005). Ecotourism and Livelihoods. Concept Publ. Company, New Delhi. **Cater, E.** (1994). Ecotourism in the third world: Problems and prospects for sustainability. **Cater and G. Lowman** Ecotourism: a sustainable option, Wiley, Chichester. **Croall, J.** (1995). Preserve or Destroy: Tourism and Environment, CalousteGulbenkian Foundation, London. **Kreg Lindberg, Deonal E. and Hawkins.** (1999). Ecotourism: A guide for Planners and Managers. Natraj Publishers, Dehradun. **Nekhvyadovich, L. I., Kuttubaeva, T. A., and Petrenko, N. E.** (2022). Ecotourism as a Basis for Sustainable Regional Development. In Geo-Economy of the Future (pp. 307-314). Springer. **Sathe, S. S. and Manepatil, U. R.** (2013). Studies on ecotourism potential of Sangli district: Case analysis with reference to places of botanical interest.	
Learning Outcomes:	Being able to work in an ecotourism industry; as ecotourism guide or tour operator; as ecotourism planner or consultant; ability to produce documentaries and movies on ecotourism.	

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Programme: M. Sc (Botany)
Course Code: BOPG-503
Title of the Course: Lab in Ecotourism.
Number of Credits: 2 (60 hours)
Effective from AY: 2022-22

Prerequisites for the course:	Basic knowledge of biology. Students should opt for BOTG-503.	
Objective(s):	• To impart training in ecotourism-based goods and services for the purpose of creating trained manpower for ecotourism projects in Goa in particular and Western Ghats. • To impart practical knowledge as short-term apprentices in ecotourism industry.	
Content:	1. Familiarizing with Ecotourism websites and portals. 2. Ecotourism films and documentaries - appreciation. 3. Production of ecotourism photo portfolio. 4. Production and display of thematic original video-film of short duration. 5. Creation of an ecotourism-themed blog or website. 6. Creating an artistic ecotourism promotional brochures, booklets or posters. 7. Submission of ecotourism project proposal in standard format. **Internship** 1. Pre-Internship work 2. Internship at assigned ecotourism facility 3. Preparation of terminal report	**4 hours** **4 hours** **4 hours** **8 hours** **4 hours** **4 hours** **4 hours** **4 hours** **20 hours** **4 hours**
Pedagogy:	Mini Projects, Hands on training, Demos, Portal and Blog Design, Photographic and videographic sessions, Field visits, Expert lectures, Videos, Apprenticeship at Ecotourism Facility.	
References/ Readings:	**Batta, A.** (2000). Tourism and Environment. Indus Publishing Co., New Delhi. **Bhattacharya, A.K.** (2005). Ecotourism and Livelihoods. Concept Publ. Company, New Delhi. **Cardoso, A. F. S., Sousa, B. B., and da Cunha, A. C. G.** (2022). Mobile Applications in Urban Ecotourism: Promoting Digitization and Competitive Differentiation. In Integrated Business Models in the Digital Age (pp. 349-369). Palgrave Macmillan. **Cater, E.** (1994). Ecotourism in the third world: Problems and prospects for sustainability. **Cater and G. Lowman** (1994)). Ecotourism: a sustainable option, Wiley, Chichester. **Croall, J.** (1995). Preserve or Destroy: Tourism and Environment, Calouste Gulbenkian Foundation, London. **Kreg Lindberg, Deonal E. and Hawkins.** (1999). Ecotourism: A guide for Planners and Managers. Natraj Publishers, Dehradun.	

Learning Outcomes:	1. Being able to find jobs in an ecotourism industry. 2. Launch one's own ecotourism project. 3. Have confidence to work as an ecotourism guide. 4. Enable to prepare market survey reports or consultancy reports on ecotourism. 5. Have ability to contribute to framing of ecotourism policies and strategies. 6. Better prospects to work as travel writer, food columnist etc. 7. Better capacity to produce documentaries and photographs on ecotourism destinations.	

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Programme: M. Sc (Botany)
Course Code: BOTG-504
Title of the Course: Mushroom Biotechnology
Number of Credits: 1
Effective from AY: 2022-23

Prerequisites for the course:	Basic knowledge of Biology.	
Objective(s):	• To impart knowledge in diversity and biology of mushrooms. • To acquire knowledge of mushroom biotechnology with respect to edible and medicinal species. • To acquire information on toxic species of mushrooms. • To gain knowledge on mushroom production and marketing.	
Content:	1. Cultivation Technology: Infrastructure, equipments and substrates in mushroom cultivation. 2. Diversity of mushrooms, edible and medicinal mushrooms, criteria for edibility, domestication of edible and medicinal mushrooms. 3. Mushroom biotechnology of commercially cultivated species. 4. Spawn development and quality parameters. 5. Production and quality management. Substrates used in mushroom production. 6. Harvesting, grading, branding, marketing. 7. Mushrooms-post harvest processing and value addition. 8. Storage and food preparation from mushrooms. 9. Mushroom marketing, scope for new species, scope in tropical countries. 10. Future of mushroom industry-global, national, local perspectives.	**1 hour** **2 hours** **1 hour** **2 hours** **2 hours** **1 hour** **2 hours** **2 hours** **1 hour** **1 hour**
Pedagogy:	Lectures/Tutorials/Assignments/Seminars/Videos/Moodle based guidance/Expert Lectures.	
References/ Readings:	**Board N.** (2006). Handbook on Mushroom Cultivation and Processing: With Dehydration, Preservation and Canning: Asia Pacific Business Press, 522 pp. **Biswas S., Datta M. and Ngachan S.V.** (2007). Mushrooms: A Manual for Cultivation: PHI Learning, 220 pp.	

Chang, S.T. and W. A. Hayes (2013). The Biology and Cultivation of Edible Mushrooms. Academic Press Inc., New York, New York. 819 pp.

Dutta, R. (2007). Advances in mushroom science. Satish Serial Publishing House, Delhi.

Gogoi Robin, Rathaiah Yella and Borah Tasvina Rahman (2006). Mushroom Cultivation Technology: Scientific, 130 pp.

Jana B.L. (2014). Mushroom Culture: Agrotech Publishing Academy, 152 pp.

Kannaiyan S., Marimuthu T. and Lenin K. (Ed) (2011), Diversity and Production of Edible Mushrooms: Associated Publishing Company, 184 pp.

Kuo, M. (2007). 100 Edible Mushrooms. Ann Arbor: University of Michigan Press. 329 pp.

Kumar, A., and Satpathy, A. (2022). Cultivation of Two Edible Mushrooms and Need for Training of Mushroom Production Technology to Enhance Rural Economy. In Biology, Cultivation and Applications of Mushrooms (pp. 561-577). Springer, Singapore.

Largent, D.L., Johnson, D. and Watling, R. (1973). How to identify mushrooms to genus III: Microscopic features. Eureka, CA: Mad River Press. 148 pp.

Largent, D.L. and Baroni, T.J. (1988). How to identify mushrooms to genus VI: Modern genera. Eureka, CA: Mad River Press. 277 pp.

Moser, M. (1983). Keys to Agarics and Boleti (Polyporales, Boletales, Agaricales, Russulales). Ed. Kibby, G. Transl. Plant, S. London: Roger Phillips. 535 pp.

Pacific Northwest Key Council (2006). Keys to mushrooms of the Pacific Northwest. Retrieved from the Pacific Northwest Key Council.

Pathak V.N., Yadav Nagendra and Gaur Maneesha (2011). Mushroom Production and Processing Technology: Agrobios, 180 pp.**Phillips, R.** (1991). Mushrooms of North America. Boston: Little, Brown and Company. 319 pp.

Ram Aavishkar R.C. (2007). Mushrooms and Their Cultivation Techniques. 164 pp.

Roberts, P. and Evans, S. (2014). The Book of Fungi: A Life-Size Guide to Six Hundred Species from Around the World. United Kingdom: Ivy Press.

Singh J.K. (2012). Mushroom: Diseases and Its Control: Enkay Pub, 264 pp.

Singh Reeti and Singh U.C. (2011). Modern Mushroom Cultivation: Agrobios, 229.

	Singh S.K. and Jha P.K. (2014). Mushroom: Production and Utilization: Scientific Publishers, 2014, 189 pp. **Suman B.C. and Sharma V.P.** (2014). Mushroom Cultivation in India: Daya, Reprint, 180 pp. **Verma B.N., Prasad Prem Kumar and Sahu K.K.** (2013). Mushrooms: Edible and Medicinal Cultivation Conservation Strain Improvement with their Marketing: Daya, 431 pp.	
Learning Outcomes:	1. Enable to appreciate the ethnomycological traditions and role of edible mushrooms in culture and economy. 2. Enable to independently handle and culture edible mushrooms. 3. Enable to analyze mushroom production and marketing trends. 4. Enable to work in a mushroom industry.	

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Programme: M. Sc (Botany)
Course Code: BOPG-504
Title of the Course: Lab in Mushroom Biotechnology
Number of Credits: 1 (30 hours)
Effective from AY: 2022-23

Prerequisites for the course:	Basic knowledge of biology. Students should opt for BOTG-504.	
Objectives:	• To impart training in aspects of production, quality evaluation, marketing of edible mushrooms and their nutritional importance.	
Content:	1. Identification of mushroom habitats. 2. Identification of edible, medicinal and toxic mushroom species. 3. Preparation of culture, preparation of mother spawn and multiplication. 4. Obtaining and studying mushroom spore prints. 5. Developmental biology of local wild mushrooms. 6. Preparation of pure mushroom cultures. 7. Production of SCPs (single cell proteins) from submerged culture of edible mushrooms. 8. Production and evaluation of mushroom spawn. 9. Processing and preservation of mushrooms, economics of spawn and mushroom production. 10. Oyster mushroom cultivation using tissue paper rolls and any other substrate. 11. Mushroom quality evaluation- button or oyster mushrooms. 12. Visit to mushroom industry and submission of report.	**2 hours** **2 hours** **4 hours** **2 hours** **2 hours** **2 hours** **4 hours** **2 hours** **4 hours** **2 hours** **2 hours** **2 hours**
Pedagogy:	Practical Exercises, Hands on training, Videos, Moodle based guidance.	

References/ Readings:	**Arora, D.** (1986). Mushrooms demystified: A comprehensive guide to the fleshy fungi. Berkeley: Ten Speed Press. 959 pp. **Kuo, M.** (2007). 100 Edible Mushrooms. Ann Arbor: University of Michigan Press. 329 pp. **Kuo, M. and A. Methven** (2010). 100 Cool Mushrooms. Ann Arbor: University of Michigan Press. 210 pp. **Kumar, A., and Satpathy, A.** (2022). Cultivation of Two Edible Mushrooms and Need for Training of Mushroom Production Technology to Enhance Rural Economy. In: Biology, Cultivation and Applications of Mushrooms (pp. 561-577). Springer, Singapore.**Largent, D. L.** (1973). How to identify mushrooms to genus I: Macroscopic features. Eureka, CA: Mad River Press. 86 pp. **Largent, D. L. and Thiers, H. D.** (1973). How to identify mushrooms to genus II: Field identification of genera. Eureka, CA: Mad River Press. 32 pp.	
Learning Outcomes:	1. Enable to cultivate edible mushrooms and produce quality mushroom spawn. 2. Prospects to work in a mushroom industry. 3. Enable to prepare consultancy reports on mushroom production and marketing. 4. Enable to work as master trainer in mushroom cultivation camps or workshops.	

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Programme: M. Sc Botany
Course Code: BOTG-505
Title of the Course: Marine Phytoplanktons
No. of Credits: 1
Effective from AY: 2022-23

Prerequisites for the course:	Basic knowledge of algae.	
Objective(s):	• To impart training in identification of microalgae. • To impart knowledge in phytoplankton ecology. • To impart knowledge on economic importance of phytoplanktons.	
Content:	1. Taxonomic and Ecological Classification of Phytoplankton. Ecological Roles. 2. **Marine Diatoms**: General characteristics, Life cycle, Morphology and terminology with respect to centric and pennate diatoms Diatomite-industrial mineral, Calcareous algal fossils and their products algal kerogen in petroleum and coal. 3. **Marine Dinoflagellates**: General characteristics, Morphology and terminology, Microanatomy, Taxonomy, Bloom dynamics and impacts: Initiation, Growth, Maintenance, and Termination. Ecological and Economic impacts: Negative and Positive impacts. Harmful algal blooms in India.	**2 hours** **3 hours** **3 hours**

	4. **Planktonic Microflagellates:** General characteristics, Morphology and terminology, Taxonomy of Chromophyta, Cryptophyta and Raphidophyta, Chrysophyta (Dictychophyceae, Prymnesiophyceae- Haptophyceae) Chlorophyta (Euglenophyta, Prasinonohyta and Chlorophtya). Coccolothophorids: Holococolithophorids and heterococcolithophorids. 5. **Marine biofouling**: Bacterial, Microalgal and Macroalgal biofouling, control treatments; antifouling coatings. Recent improvements in Chemical control, Biological control, Non-adhesive surfaces. 6. Identification, Collection, preservation, and preparation techniques for the plankton groups.	**3 hours** **2 hours** **2 hours**
Pedagogy:	Lectures/Tutorials/Assignments.	
References/ Readings:	**Fritsch, F.E.** (1935). The Structure and Reproduction of the Algae. Cambridge University Press. **Hallegraeff, G.A**. (1993). A review of harmful algal blooms and their apparent global increase. Phycologia 32, 79-99. **Hallegraeff, G.M., Anderson, D.M. and Cembella, A.D.** (2003). Manual on Harmful Marine Micro-algae. UNESCO. **Hargraves, P.E. and French, F.W**. (1983). Diatom resting spores: Significance and strategies. In: Fryxell, G. A. (Ed.), Survival Strategies of the Algae. pp. 49-68. Cambridge: Cambridge University Press. **Reynolds C. S**. (2014) The Ecology of Phytoplanktons, Cambridge University Press, New York	
Learning Outcomes:	1. Enable to identify the marine microalgae. 2. Enable to work as Assistant in Environmental Monitoring Programme.	

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Programme: M. Sc. (Botany)
Course Code: BOTG-506
Title of the Course: Oenology
Number of Credits: 1
Effective from AY: 2022-23

Prerequisites for the course:	Basic knowledge of biology.	
Objective(s):	• To understand the basics of oenology. • To understand the origin, history and concept of wine tasting. • To impart training on small-scale fruit wine production.	
Content:	1. Overview of Oenology, ancient and modern methods of wine making. 2. Viticulture and Grape species. 3. Wine Types and Styles, Wine Regions and Terroir, the Indian wine scene.	**1 hour** **1 hour** **1 hour**

	4. Harvesting and processing of grapes and other fruits. 5. Sources of contamination in wine making; Sanitation and Sterilization. 6. Scales of winemaking, micro-vinification, Materials and supplies used in wine making. 7. Chemistry and cell biology of fermentations with yeast and bacteria. 8. Fermentation processes; Post-fermentation. 9. Wine analysis; Chemical components of Wine; Biochemical reactions in fermentation. Winery by-products and their management. 10. Wine acids, Aroma compounds (Terpenes), colour and flavour compounds (phenolics, Tannins). 11. Sensory evaluation and quality control in wine making. 12. Wine microbial spoilage and its control; Wine defects and remedies. 13. Wine bottling, corking, packaging, branding and marketing strategies. 14. Alcohol marketing laws (India and Worldwide); Revenue system in Goa and other States. 15. Alcohol regulatory policies; State excise policies in Goa and other States.	**1 hour** **1 hour** **1 hour** **1 hour** **1 hour** **1 hour** **1 hour** **1 hour** **1 hour** **1 hour** **1 hour** **1 hour** **1 hour**
Pedagogy:	Lectures/Tutorials/Assignments/Seminars/Videos/Expert-Lectures/Industrial visits/Moodle based guidance.	
References/ Readings:	**Amerine, M.A., Berg, H.W., Kunkee, R.E., Ough, C.S., Singleton, V.L. and Webb, A.D.** (1980). The Technology of Winemaking. 4th edition. AVI Publishing Co. Inc. Westport. **Amerine, M.A. and Roessler, E.B.** (1983). Wines: Their sensory evaluation. WH Freeman & Co. San Francisco. **Amerine, M.A. and Singleton, V.L.** (1977). Wine: An Introduction to the Wines of the World, Grape Cultivation, Techniques of Wine-making, and how to evaluate and Enjoy Wines. University of California Press. **Fleet, G.H.** (1993). Wine Microbiology and Biotechnology. Harwood Academic Publishers, Chur. **Fugelsang, K.C.** (1997). Wine Microbiology. Chapman & Hall, New York. **Jackson, R.S.** (2000). Wine Science: Principles, Practice, Perception. Second Edition. Academic Press, Inc., 525 B Street, Suite 1900, San Deigo, California. **Jordão, A.M., and Cosme, F. (**2022). The Application of Wood Species in Enology: Chemical Wood Composition and Effect on Wine Quality. Applied Sciences, 12(6), 3179. **Linskens, H. F. and Jackson, J.F.** (1988). Wine Analysis: Modern Methods of Plant Analysis. New series volume 6. Springer Verlag.	

	Ough, C.S. (1991). Winemaking Basics. Food Products Press, New York. **Ribereau-Gayon, P., Dubourdieu, D. and Doneche, B.A. Lonvaud**. (2000). Handbook of Enology Volume 1: Microbiology of Wine and Vinifications. John Wiley and Sons, New York. **Ribereau-Gayon, P., Glories, Y.A. Maugean and Dubourdieu, D.** (2021). Handbook of Enology Volume 2: Microbiology of Wine, The Chemistry of Wine Stabilization and Treatments. John Wiley and Sons, New York. **Schahinger, G. and Rankine, B.** (1992). Cooperage for Winemakers: A manual on the construction, maintenance, and use of oak barrels. Ryan Publications, Adelaide, South Australia. **Storm, D.R.** (1997). Winery utilities: planning, design and operation. Chapman and Hall, New York. **Vine, R.P.** (1981). Commercial Winemaking, Processing and Controls. AVI Publishing Co., Westport, CT. **Vine, R.P., Harkness E.M., Browning, T., Wagner, C. and Bordelon, B.** (1997). Winemaking: from grape growing to marketplace. Chapman and Hall, New York. **Waterhouse, A.L. and Ebeler, S.E.** (1998). Chemistry of Wine Flavor. American Chemical Society, Washington, D.C. **Yendell, K.** (2015). Winemaking: Fermenting, Pressing, Bottling, and Aging: An Introduction to Oenology. United States: CreateSpace Independent Publishing Platform. **Enological websites** • Academic study of winemaking from the University of California, Davis http://www.wineserver.ucdavis.edu • Web site for American journal of oenology and viticulture. http://www.ajevonline.org • Internet journal of viticulture and oenology http://www.infowine.com	
Learning Outcomes:	• Enable to understand international trends in production and marketing of wines; define a terroir. • Enable to appreciate the role of wine in culture, religion, industry and economy. • Enable to assist in wine industry. • Prospects in tourism industry.	

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Programme: M. Sc. (Botany)
Course Code: BOPG-506
Title of the Course: Lab in Oenology
Number of Credits: 1 (30 hours)
Effective from AY: 2022-23

Prerequisites for the course:	Basic knowledge of Biology. Students should opt for BOTG-506.	
Objective(s):	• To make students employable as oenologists.	
Content:	1. Identification of different wine making equipments. 2. Culture and examination of different yeast strains used for wine making. 3. Microscale production of grape wine. 4. Monitoring of fermentation parameters of grape wine using refractometer and hydrometer. 5. The organization of wine evaluation: the space, equipment, temperature, order of serving the wines. 6. Benchtop production and monitoring of wines from fruits, spices and condiments. 7. Organosensory evaluation of grape and other fruit wines. 8. Analysis of alcohol content in wine. 9. Analytical testing in wine making (Reducing sugars, pH, Acidity, Ammonia nitrogen, Sulphur dioxide, Turbidity, Dissolved oxygen). 10. Report on wine brands and wine marketing. ***Any 30 hours of the above practicals will be conducted.***	**2 hours** **2 hours** **4 hours** **4 hours** **2 hours** **10 hours** **2 hours** **2 hours** **4 hours** **4 hours**
Pedagogy:	Lab exercises/Demos/Field visits/Industrial visits/Expert Lectures/Videos.	
References/ Readings:	**Boulton, R. B., Singleton, V. L., Bisson, L. F. and Kunkee, R. E.** (1996). Principles and Practices of Winemaking. Chapman and Hall, New York. **Fleet, G. H.** (1993). Wine Microbiology and Biotechnology. Harwood Academic Publishers, Chur. **Fugelsang, K. C.** (1997). Wine Microbiology. Chapman and Hall, New York. **Iland, P, Ewart, A. and Sitters, J.** (1993). Techniques For Chemical Analysis and Stability Tests of Grape Juice and Wine. Patrick Iland Wine Promotions, PO Box 131, Campbelltown, South Australia 5074. **Iland, P.** (1991). An Introduction to Wine: A Guide to the Making, Tasting, and Appreciation of Wine. Patrick Iland Wine Promotions, PO Box 131, Campbelltown, South Australia 5074. **Pougnet, S., Martin-Rios, C., and Pasamar, S.** (2022). Keg wine technology as a service innovation for sustainability in the foodservice industry. Journal of Cleaner Production, 132145. **Tsegay, Z. T., Sathyanarayana, C. B., and Lemma, S. M.** (2018). Optimization of cactus pear fruit fermentation process for wine production. Foods, 7(8), 121. **Tsegay, Z. T., and Gebremedhin, K. M.** (2019). Physicochemical and sensory properties of wine produced from blended Cactus	

	Pear (*Opuntia ficus-indica*) and *Lantana camara* Fruits. Journal of Food Quality. **Velchev** (2017) Wine Informatics: A quantitative analysis of wine reviewers https://uca.edu/cse/files/2020/02/Wineinformatics-A-Quantitative-Analysis-of-Wine-Reviewers.pdf	
Learning Outcomes:	**Ability to:** produce fruit wines on small scale; carryout sensory evaluation of wines; work as a trainee oenologist, wine journalist or columnist; join hospitality sector as an expert on elite brands of wines.	

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Programme: M. Sc (Botany)
Course Code: BOTG-507
Title of the Course: Ethnobotany.
Number of Credits: 2
Effective from AY: 2022-23

Prerequisites for the course:	Basic knowledge of Botany.	
Objective(s):	• To impart knowledge in ethnobotany, methods of collecting ethnobotanical data and commercial use of traditional knowledge.	
Content:	1. Introduction: Brief history of ethnobotanical studies in the world and in India; Scope of ethnobotany. Sub disciplines of ethnobotany. Interdisciplinary approaches. Knowledge of sociological and anthropological terms. 2. Distribution of tribes in India. Knowledge of tribes of Konkan, Goa and Kanara; Ethnobotanical work on these tribes. 3. Sources of ethnobotanical data: Primary - archaeological sources and inventories, Secondary - travelogues, folklore and literary sources, herbaria, medicinal texts and official records. Methods in ethnobotanical research. Research design and cautions in data collections, Practical and field skills; Prior informed consent, Participatory Rural Appraisal (PRA) techniques, interviews and questionnaire methods, choice of resource persons. 4. Ethnobotanical knowledge and communities: Ethnobotanical classification; Folk taxonomy of plants. Non-Timber Forest Produce (NTFP) and livelihood. Sustainable harvest and value addition. Ethno-mycology. Conservation and community development. 5. Bioprospecting and commercial use of traditional knowledge; Medical ethnobotany, ethno-pharmacology and the search of plant-based drugs. Developing research partnerships: Ethics and research guidelines in ethnobotany, equitable research relationships.	**5 hours** **5 hours** **5 hours** **5 hours** **5 hours**

	6. Traditional knowledge (TK) in relation to Intellectual Property Rights and Biopiracy. Equitable Benefit sharing models of the world. 7. Ethnobotany and People's Biodiversity Register (PBR). Practical applications of ethnobotanical data; Ethno-medicine and primary health care; Ethnobotany and ethno-pharmacology as a tool to protect interests of ethnic groups and rural development.	**3 hours** **2 hours**
Pedagogy:	Lectures/ Tutorials/Assignments.	
References/ Readings:	**Alexiades, M. (**1996**).** Selected guidelines for ethnobotanical research: A field manual. New York: New York Botanical Garden. **Apte, T. (**2006**).** Intellectual Property Rights, Biodiversity and Traditional Knowledge. Kalpavriksh, Grain and IIED, Pune / New Delhi. **Balee W. L. (**2003). Footprints of the Forests. Bishen Singh Mahendar Pal Singh, Dehra Dun, India. **Balick, M. and P. A. Cox. (**1996). Plants, People, and Culture: The Science of Ethnobotany. Scientific American Library, New York. **Begossi, A. (**1996**).** Use of ecological methods in ethnobotany. Economic Botany 50 (3): 280–89. **Chauhan, S., and Chauhan, S. V. S.** (2019). Worship and trees in India. Siberian Journal of Forest Science, 4: 36-48. **Cotton, C. M. (**1997). Ethnobotany – Principles and Applications. John Wiley and Sons Limited. New York, USA. **CSIR. (**1940-1976). Wealth of India. A Dictionary of Raw Materials and Industrial Products - Raw Materials.Vol.1-11. CSIR Publication and Information Directorate. New Delhi. **Jain, A. K.** (2016). Indian ethnobotany: emerging trends. Scientific Publishers.	
Learning Outcomes:	1. Enable students to understand the importance of traditional knowledge systems in ethnobotany important for GIP and pharma industry. 2. Ability to interact with tribes and other medicinal practitioners and people having special knowledge of medicinal and other useful plants. 3. Career with NGOs involved in documenting tribal knowledge.	

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Research Specific Electives Courses

Programme: M. Sc (Botany)
Course Code: BOTR-501
Title of the course: Plant Histochemistry
Number of Credits: 3

Effective from AY: 2022-23

Prerequisites for the course:	Basic knowledge of Botany.	
Objective(s):	• To understand the structure and development of plants. • To gain knowledge on applications of microscopy and use of instrumentation. • To understand the methods and procedures for localization of various storage compounds such as carbohydrates, protein, lipids, minerals such as calcium, potassium, iron and other chemical compounds present in different parts of plants using fluorescent and non-fluorescent dyes.	
Content:	1. **Introduction to basic histology:** Cells, tissues and microorganisms. 2. **General Techniques:** Chemistry and practice of fixation; whole mounts; sectioning-microtomy, cryo- and ultra-microtomy; freeze-drying of biological materials. 3. **Microscopy:** Light matter interaction and its significance; Kohler illumination; Principles, instrumentation and applications of bright-field, polarization, phase-contrast, fluorescence, confocal; image analyzing system. 4. **Cyto- and histo-chemistry with bright-field microscopy:** Single and double staining protocols; localization of various biogenic components such as carbohydrates, proteins, lipids, nucleic acids, phenolic compounds, lignins, cutins, suberin, waxes, minerals such as calcium, potassium, irons and other metals. 5. **Polarization microscopy:** Study of structure and components of cell wall, starch, crystals and other anisotropic materials. 6. **Fluorescence microscopy:** Auto-fluorescence in biological materials; fluorochromes; excitation filters; localisation of proteins, lysine rich proteins, lipids, nucleic acids, phytins, phenolic compounds, lignins and cutins in various biological tissues using fluorescent dyes; Role of fluorescein isothiocyanate (FITC) bound dextrins and vascular tissue specific fluorochromes in biology; study of cell membranes, connective tissues, protoplasts and infected materials. 7. **Histochemical localization of secondary metabolites:** Alkaloids, Phenolic compounds, Terpenoids and other compounds. 8. **Electron microscopy:** Principles, instrumentation, and applications of Scanning Electron Microscopy (SEM) and Transmission Electron Microscopy (TEM). Specimen preparation for TEM and SEM. 9. **Enzyme histochemistry:** Localization of esterases; phosphates and other enzymes.	**1 hour** **3 hours** **12 hours** **5 hours** **2 hours** **5 hours** **3 hours** **3 hours**

	10. **Immunohistochemistry and its application.** 11. **Photomicrography:** Basic techniques of image capturing and image analysis using bight-field, polarization, dark-field and fluorescence microscopy; Conventional and digital photography; basic principles, cameras, lenses, focusing, exposure, resolution, depth of field, lighting, keeping and storing records. 12. **Cyto-histochemistry and its applications:** Understanding biological structures of medicinal and other economically important plants; Applications in diagnostic and analytical sciences and biotechnology.	**2 hours** **1 hours** **4 hours** **4 hours**
Pedagogy:	Lectures/ Tutorials/Assignments/Seminars.	
References/ Readings:	**Chakraborty M.** (2012). Histology and Histochemistry, Wisdom Press, New Delhi. **Clark, G.** (1981). Staining Procedures, Williams and Wilkins, Baltimore, USA. **Conn. H.J.** (1977). Biological Stains. R. D. Lillie (Ed.) The Williams and Wilkins Co., Reprinted by Sigma Chemical Company, USA. **David L. Spector and Robert D. Goldman.** (2006). Basic methods in microscopy, Cold Spring Harbor Laboratory Press, Cold Spring Harbor, New York. **Gartner, L.P. and Hiatt, J.L.** (2006). Color Textbook of Histology e-book. Elsevier Health Sciences. **Hayat, M.A.** (1986). Basic Techniques for Transmission Electron Microscopy. Academic Press. London and New York. **Jensen, W.A.** (1962). Botanical Histochemistry Principles and Practice. W. H. Freeman and Company, San Francisco, USA. **Kiernan J.A.** (2008). Histological and Histochemical Methods: Theory and Practice (4th edition), Scion Publishing Ltd., UK. **Krishnamurthy, K.V.** (1988). Methods in Plant Histochemistry. S. Viswanthan (Printers & Publishers) Pvt. Ltd., Chennai. **Lacey, A. J.** (1989). Light microscopy in biology a practical approach, IRL Press, Oxford University, UK. **Pears, A.G.E.** (1980). Histochemistry Theoretical and Applied, Preparative and Optical Techniques. Vol. I. Fourth Edition. Churchill Livingstone. London and New York. **Pears, A.G.E.** (1985). Histochemistry Theoretical and Applied. Analytical Technology. Vol. II, Churchill Livingstone. London and New York. **Sharma, V.K.** (1991). Techniques in Microscopy and Cell Biology, Tata McGraw-Hill Publishing Company Limited, New Delhi.	

	Shyamasundari, K. and K. Rao H. (2007). Histochemistry in focus. A Source book of techniques and research needs, MJP Publishers, Chennai. **Zhou, J. and Xi'an J.** (2017). Histochemistry, University Press Co. Germany: De Gruyter.	
Learning Outcomes:	1. Able to gain insight in fine structure of plant tissues and apply the knowledge of histochemical and microscopic techniques to understand development of various plant species. 2. Able to select appropriate stains to differentiate plant tissues in different stages of development. 3. Able to apply methods and procedures for localization of various compounds, enzymes, minerals, etc. 4. Prospects in pharmacognosy.	

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Programme: M.Sc (Botany)
Course Code: BOPR-501
Title of the course: Lab in Plant Histochemistry
Number of Credits: 1 (30 hours)
Effective from AY: 2022-23

Prerequisites for the course:	Basic knowledge of Botany.	
Objective(s):	• To learn and understand various microscopic and histochemical techniques. • To understand localization of various storage compounds such as starch, protein, lipids, minerals, secondary metabolites and other compounds using various fluorescent and non-fluorescent dyes.	
Content:	1. Study of auto-fluorescence in biological specimens using UV, violet, blue and green excitation filters under fluorescence microscopy. 2. Localization of proteins in biological tissues using fluorescent and non-fluorescent dyes. 3. Localization of lipids in biological tissues using fluorescent and non-fluorescent dyes. 4. Study of cell wall structure using the specific fluorochrome like calcofluor white or acridine orange using fluorescence microscopy. 5. Study the distribution of starch in biological specimens using iodine potassium iodide. 6. Study the structure of starch, stomata, crystalline and other anisotropic materials using polarization microscopy. 7. Examination of normal and diseased plant tissues using fluorescence microscopy. 8. Localization of plant cell nuclei using fluorescent and non-fluorescent dyes.	**2 hours** **4 hours** **4 hours** **2 hours** **2 hours** **2 hours** **2 hours** **4 hours** **6 hours**

	9. Localization of minerals such as calcium, potassium and iron in biological tissues. 10. Microphotography using bright-field, dark-field, polarization and fluorescence microscopy. 11. Demonstration of image capture, image analysis, measurement of various parameters of cells and tissues using image analyzing software. 12. Demonstration of Scanning Electron Microscopy (SEM). 13. Extraction of natural dyes from plants. 14. Evaluation of natural dyes as biological stains. ***Any 30 hours of the above practicals to be conducted.***	**2 hours** **2 hours** **2 hours** **2 hours** **2 hours**
Pedagogy:	Hands on Practical/Demonstrations.	
References/ Readings:	**Clark, G.** (1981). Staining Procedures, Williams and Wilkins, Baltimore, USA. Conn. H.J. 1977. Biological Stains. R. D. Lillie (Ed.) The Williams and Wilkins Co., Reprinted by Sigma Chemical Company, USA. **David L. Spector and Robert D. Goldman.** (2006). Basic methods in microscopy, Cold Spring Harbor Laboratory Press, Cold Spring Harbor, New York. **Hayat, M.A.** (1986). Basic Techniques for Transmission Electron Microscopy. Academic Press. London and New York. **Jensen, W.A.** (1962). Botanical Histochemistry Principles and Practice. W. H. Freeman and Company, San Francisco, USA. **Kiernan John A.** (2008). Histological and Histochemical Methods: Theory and Practice (4th edition), Scion Publishing Ltd., UK. **Krishnamurthy, K.V.** (1988). Methods in Plant Histochemistry. S. Viswanthan (Printers and Publishers) Pvt. Ltd., Chennai. **Lacey, A. J.** (1989). Light microscopy in biology a practical approach, IRL Press, Oxford University, UK. **Meenakshi Chakraborty.** (2012). Histology and Histochemistry, Wisdom Press, New Delhi. **Pears, A.G.E.** (1980). Histochemistry Theoretical and Applied, Preparative and Optical Techniques. Vol. I. Fourth Edition. Churchill Livingstone. London and New York. **Pears, A.G.E.** (1985). Histochemistry Theoretical and Applied. Analytical Technology. Vol. II, Churchill Livingstone. London and New York. **Sharma, V. K.** (1991). Techniques in Microscopy and Cell Biology, Tata McGraw-Hill Publishing Company Limited, New Delhi. **Shyamasundari, K. and K. Hanumantha Rao.** (2007). Histochemistry in focus. A Source book of techniques and research needs, MJP Publishers, Chennai.	

	Zhou, J. and Xi'an Jiaotong (2017). Histochemistry, University Press Co. Germany: De Gruyter.	
Learning Outcomes:	1. Enable to gain insight in fine structure of plant tissues and apply the knowledge of histochemical and microscopic techniques to understand the development of various plant species. 2. Enable to select appropriate stains to differentiate plant tissues in different stages of development. 3. Enable to apply methods and procedures for localization of various compounds, enzymes, minerals, primary and secondary metabolites, etc. 4. Enable to extract and use natural dyes as biological stains. 5. Prospects in pharmacognosy.	

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Programme: M. Sc (Botany)
Course Code: BOTR-502
Title of the Course: Seed Science and Technology
Number of Credits: 3
Effective from AY: 2022-23

Prerequisites for the course:	Basic knowledge of Botany.	
Objective(s):	• To facilitate deeper understanding of various aspects of seed science and technology.	
Content:	1. **Concept of seed technology**: Seed quality, definition, importance and goals of seed technology; types of seed programmes; Steps involved in development of a seed programme. Characters of good quality seeds, Seed development and maturation. 2. **General Principals of seed production and Seed Processing:** Genetic and agronomic principles; Maintenance of nucleus seed; production of Breeder, Foundation and Certified seed; principles of seed processing; methods of seed drying. 3. **Seed cleaning equipment and their functions:** Functions of Scalper, Debearder, Scarifier, Huller, Seed Cleaner and Grader. Screen cleaners, specific gravity separator, indented cylinder, velvet-spiral-disc separators, colour sorter, delinting machines. 4. **Seed treatment:** Types of seed treatment, seed treating formulations and equipments, seed disinfestations, identification of treated seeds; packaging materials: principles, practices and materials; bagging and labelling. Seed quality enhancement techniques, seed priming, seed coating and seed pelleting. 5. **Seed storage:** Principles of seed storage; seed drying, importance of seed drying; factors affecting seed longevity during storage, changes during storage, concepts and significance of moisture equilibrium, methods of maintaining safe seed moisture content. Methods to minimize the loss of seed vigour and viability; factors	**5 hours** **5 hours** **5 hours** **5 hours** **10 hours**

	influencing storage losses. Measures for pest and disease control during storage and godown sanitation; Storage structures. Storage problems of recalcitrant seeds and their conservation. Genetic changes during seed storage; Seed marketing-structure and organization; factors affecting seed marketing and demand. 6. **Seed germination methods:** Germination-phases of seed germination; Dormancy-types of seed dormancy; TTC test; Embryo excision method. 7. **Field Inspection:** Method of inspection; field counts; field and seed standards; post-harvest inspection; specifications for tags and labels. Duties and powers of Seed Inspector. 8. **Seed Certification:** Objectives of seed certification; legal status and phases of seed certification; procedure for seed certification; formulation, revision and publication of seed certification standards. 9. **Seed Legislation and Seed Law Enforcement:** Seed Act and rules; Seed Legislation in India; Regulatory legislations; Seed Law Enforcement; Seed Control Order, 1983; The Plant Varieties Act, National Seed Policy 2002; Seed Bill 2004.	**5 hours** **3 hours** **3 hours** **4 hours**
Pedagogy:	Lectures/Assignments/Moodle/Tutorials/Seminars.	
References/ Readings:	**Agarwal, R. L.** (2018). Seed Technology. India: Oxford and IBH Publishing Company Pvt. Limited. **Agrawal P.K.** (1993). Handbook of Seed Testing. Ministry of Agriculture, GOI, New Delhi. **Agrawal P.K. and Dadlani M.** (1992). Techniques in Seed Science and Technology. 2nd Ed. South Asian Publications. **Copland L.O. and McDonald M.B.** (1996). Principles of Seed Science and Technology. Kluwer. **ISTA (**2006). Seed Testing Manual. ISTA, Switzerland. **Joshi, A.K. and B.D. Singh.** (2004). Seed Science and Technology. Kalyani Publishers. **Martin C. and Barkley D.** (1961). Seed Identification Manual. Oxford & IBH. **Singh P.** (2013). Principles of Seed Technology. Kalyani Publishers. **Subir Sen and Nabinananda Ghosh.** (2014). Seed Science and Technology. Kalyani Publishers **Tunwar N.S. and Singh S.V.** (1988). Indian Minimum Seed Certification Standards. Central Seed Certification Board, Ministry of Agriculture, New Delhi.	
Learning Outcomes:	**Ability to:** work in seed banks and plant nurseries, educate farmers and seed producers, run seed distribution outlets, work as market watchdogs to detect spurious seeds, work as seed collectors.	

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Programme: M. Sc (Botany)

Course Code: BOPR-502
Title of the Course: Lab in Seed Science and Technology
Number of Credits: 1 (30 hours)
Effective from AY: 2022-23

Prerequisites for the course:	Basic knowledge of Botany.	
Objective(s):	• To facilitate deeper understanding of various aspects of seed science and technology.	
Content:	1. Identification of seeds of weeds and crops. 2. Physical purity analysis of samples of different crops. 3. Estimation of seed moisture content (oven method). 4. Seed dormancy breaking methods requirements for conducting germination test. 5. Seed germination testing in different agri-horticultural crops. 6. Viability testing by tetrazolium test in different crops. 7. Seed and seedling vigour tests. 8. Effect of drying temperature and duration on seed germination. 9. Testing coated/pelleted seeds. 10. Study of orthodox, intermediary and recalcitrant seeds. 11. Global seed germplasm resources and their conservation. 12. To test the membrane permeability of the seeds.	**2 hours** **2 hours** **2 hours** **4 hours** **4 hours** **4 hours** **2 hours** **2 hours** **2 hours** **2 hours** **2 hours** **2 hours**
Pedagogy:	Practicals/Demonstrations	
References/ Readings:	**Agarwal R.L.** (2007). Seed Technology. Oxford and IBH. **Agrawal P.K. and Dadlani M.** (1992). Techniques in Seed Science and Technology. 2nd Ed. South Asian Publications. **Agrawal P.K.** (1993). Handbook of Seed Testing. Ministry of Agriculture, GOI, New Delhi. **Copland L.O. and McDonald M.B.** (1996). Principles of Seed Science and Technology. Kluwer. **ISTA** (2006). Seed Testing Manual. ISTA, Switzerland. **McDonald, M. F. and Copeland, L. O.** (2012). Principles of Seed Science and Technology. United States: Springer US. **Martin A.C. and Barkley W.D.** (2018). Seed Identification Manual. Scientific Publishers. **Tunwar N.S. and Singh S.V.** (1988). Indian Minimum Seed Certification Standards. Central Seed Certification Board, Ministry of Agriculture, New Delhi.	
Learning Outcomes:	1. Ability to carry out seed germination tests. 2. Ability to work in seed testing labs and commercial seed companies.	

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Programme: M. Sc (Botany)
Course Code: BOTR-503
Title of the Course: Genome Informatics
Number of Credits: 3

Effective from AY: 2022-23

Prerequisites for the course:	Basic knowledge of molecular biology and computers.	
Objective(s):	• To impart hands on training in public domain software tools, demos and mini projects. • To assist the students to pick up the minimum required skill sets demanded by bio-industries. • To impart basic knowledge in analysis of genome and proteome.	
Content:	1. **Introduction to Genome Informatics**: Nature of biological data, Overview of available bioinformatics resources on the web (Web based and command line softwares), National Centre for Biotechnlogy Information (NCBI), European Bioinformatics Institute (EBI), Expert Protein Analysis System (EXPASY), ENSEMBL; Biological Databases: Nucleic acid sequence databases, GenBank, European Molecular Biology Laboratory (EMBL), DNA Databank of Japan (DDBJ); Protein sequence databases, Protein Data Bank (PDB), SwissProt/UniProtKB; Genome databases of model organisms (Plants, microbes, other organisms): Online Mendelian Inheritance in Man (OMIM), Ensembl-Plants, EMBL, Reference sequence (refseq), The Single Nucleotide Polymorphism Database (dbSNP), structural databases: Molecular Modelling Database (MMDb), Nucleic Acid Database (NDB), Complex Carbohydrate Structure Database (CCSD), derived databases, PROSITE, BLOCKS, STRING, Pfam/Prodom, Database search engines, Entrez, SRS, TAIR (The Arabidopsis Information Resource), The Rice Genome Annotation Project (TAGAP), Plant MPSS (Massively Parallel Signature Sequencing) database. 2. **Overview/concepts in sequence analysis**: Evolutionary basis of sequence alignment; Pairwise sequence alignment algorithms, Needleman and Wunsch, Smith and Waterman; Scoring matrices for nucleic acids and proteins, Multiple Domain Matrix (MDM), Blocks Substitution Matrix (BLOSUM), Point Accepted Mutation (PAM), Gap Penalties; Motifs, Domains and Patterns; Database Similarity Searches – Basic Local Alignment Search Tool (BLAST), Multiple sequence alignment, Progressive sequence alignment, Parallel Multiple Sequence Alignment Package (PRAS), CLUSTAL-W. 3. **Structural biology and molecular modelling**: Proteins - Primary, Secondary, Supersecondary, Tertiary and Quaternary structure, Nucleic acid - DNA and RNA, Carbohydrates, 3D viral structures; 3D structure visualization and simulation; Concepts in molecular modelling and introduction to molecular modelling methods; Methods to study 3D structure, Analysis of 3D structures.	**8 hours** **8 hours** **8 hours**

	Principles of protein folding and methods to study protein folding: CATH (Protein Structure Classification Database), SCOP (Structural Classification of Protein Database), FSSP (Families of Structurally Similar Proteins), Ramachandran plot; Macromolecular interactions, Protein-Protein, Protein-nucleic acids, Protein-carbohydrates. 4. **Phylogenetic analysis:** Alignment, tree building and tree evaluation, Comparison and application of Unweighted Pair Group Method with Arithmetic Mean (UPGMA), Neighbour Joining (NJ), Maximum Parsimony (MP), Maximum Likelihood (ML) methods, Bootstrapping, Jackknife; Software for Phylogenetic analysis. DNA barcoding: Methods tools and databases for barcoding across all species, Applications and limitations of barcoding, Consortium for Barcode of Life (CBOL) recommendations, Barcode of Life Database (BOLD). 5. **Analysis of DNA and Protein Microarrays:** Designing of oligo probes; primers, promoters; Analysis of Genomics sequences, promoter sequences-MEME (Motif Based Sequence Analysis Tool), e-plant, PLANTCARE, RNA sequences; Analysis of DNA for cloning: Tools, Softwares used; Image processing and normalization; Microarray data variability (measurement and quantification); Analysis of differentially expressed genes; Experimental designs, Analysis of Next Generation Sequencing data and RNA sequencing data, plant GDB for comparative Genomics. 6. **Applications in drug design:** Chemical databases like NCI/PUBCHEM; Fundamentals of Receptor-ligand interactions; Structure-based drug design: Identification and Analysis of binding sites and virtual screening; Ligand based drug design: Structure Activity Relationship – QSARs (Quantitative Structure Activity Relationship Model) and Pharmacophore; in silico predictions of drug activity and ADMET (Absorption, Distribution, Metabolism and Excretion), Molecular Docking.	**7 hours** **7 hours** **7 hours**
Pedagogy:	Lectures/Tutorials/Seminars/Assignments.	
References/ Readings:	**Andrew Leach**. (2001). Molecular Modelling: Principles and Applications, Prentice Hall. **Antao, T.** (2018). Bioinformatics with Python Cookbook: Learn how to use modern Python bioinformatics libraries and applications to do cutting-edge research in computational biology. Packt Publishing Ltd. **Attwood, T. K., Parry-Smith, D. J. and Phukan S.** (2022). Introduction to Bioinformatics Delhi. Pearson Education (Singapore) Ptd. Ltd.	

Baxevanis, A.D., Davison, D.B., Page, R.D.M. and Petsko, G.A. 2004. Current Protocols in Bioinformatics by, New York, John Wiley and Sons Inc.

Bujnicki, J. M., Droogmans, L., Grosjean, H., Purushothaman, S. K., and Lapeyre, B. (2008). Practical Bioinformatics. Springer.

Dov Stekel, (2003); Microarray Bioinformatics; Cambridge University Press.

Fasman, G.D. (1989). Prediction of protein structure and the principles of protein conformation. New York. Plenum Press.

Friesner, R.A. Ed., Prigogine, L. Ed. and Rice, S.A. (2002). Computational methods for protein folding: advances in chemical physics vol. 120. New York. John Wiley and sons, Inc. Publication.

Gimona, G. Cesareni and Yaffe, M. Sudol (Eds). (2004). Modular protein domains, USA, Wiley-vch Verlag gmbh and co. 3-527-30813-X.

Gundertofte, K. and Jorgensen, F.S. (2000). Molecular modelling and prediction of bioactivity, New York. Kluwer Academic Publishers.

Madhavan, G. (2006). Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins. Edited by Andreas D. Baxevanis and BF Francis Ouellette, ISBN: 0-471-47878-4.

Maulik, U., Bandyopadhyay, S., and Mukhopadhyay, A. (2011). Multiobjective genetic algorithms for clustering: applications in data mining and bioinformatics. Springer Science and Business Media.

Mount, David. 2004. Bioinformatics: Sequence and Genome Analysis. New York, Cold Spring Harbor Laboratory Press.

Rastogi, S.C., Mediratta, N. and Rastogi. P. 4th ed (2013). Bioinformatics, methods and applications, genomics, proteomics and drug discovery, Prentice Hall of India, Pvt. Ltd., New Delhi.

Stephen Misener and Stephen Krawetz. (2004). Bioinformatics, methods and protocols, methods in molecular biology, Volume 132, Humana Press, New Jersey, Third Indian reprint

Webster, D.M. Ed. (2000). Protein structure prediction: methods and protocols, Totowa Humana Press, 2000.

Public domain database/tools/resources

- DBGET-http://www.genome.jp/dbget/
- LinkDB-http://www.genome.jp/dbget/linkdb.html
- Fgeneshttp://www.softberry.com/berry.phtml?topic=products GeneBuilder
- http://www.itb.cnr.it/sun/webgene/
- GeneSCAN-http://genes.mit.edu/GENSCAN.html
- GRAIL-http://compbio.ornl.gov/Grail-1.3/

	• CLC Free Workbench http://www.clcbio.com/index.php?id=28 BioEditor-http://bioeditor.sdsc.edu/ • CN3D 4.1 - http://www.ncbi.nlm.nih.gov/Structure/CN3D/cn3d.shtml Protein Explorerhttp://www.umass.edu/microbio/chime/pe_beta/pe/protexpl/f rntdoor.htm • Chimera-http://www.cgl.ucsf.edu/chimera/ • Yasara-http://www.yasara.comhttp://www.yasara.com) • Ribosome builder-http://rbuilder.sourceforge.net/ • ArrayExpress-www.ebi.ac.uk/arrayexpress/ • EPICLUST-http://ep.ebi.ac.uk/EP/	
Learning Outcomes:	1. Enable to understand the basic theory of computational tools and to gain working knowledge. 2. Enable to analyse Next Generation Sequencing (NGS) raw data. 3. Would be better equipped to investigate specific contemporary biological questions.	

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Programme: M. Sc (Botany)
Course Code: BOPR-503
Title of the Course: Lab in Genome Informatics
Number of Credits: 1 (30 hours)
Effective from AY: 2022-23

Prerequisites for the course:	Basic knowledge of molecular biology and computers.	
Objective(s):	• To provide practical experience in using common computational tools and databases. • To facilitate investigation of molecular biology and evolution-related concepts. • To train in modern methods of biological analysis.	
Content:	1. Exploring National Centre for Biotechnology Information (NCBI) database, PUBMED and GenBank databases, (NCBI), European Bioinformatics Institute (EBI) server and searching the European Molecular Biology Laboratory (EMBL) Nucleotide database, Entrez (Global Query Cross-Database Search System), SWISSPROT & UniProtKB. 2. Sequence retrieval of DNA and Protein from different databases. 3. Homology searches using different versions of Basic Local Alignment Search Tool (BLAST) and interpretation of the results to derive the biologically significant relationships of the query sequences (proteins/DNA) with the database sequences. 4. Use of scoring matrices, Pair-wise local alignments of protein and DNA sequences using Smith-Waterman algorithm and interpretation of results.	**2 hours** **2 hours** **2 hours** **2 hours**

	5. Multiple sequence alignments of sets of sequences using web based and stand-alone version of CLUSTAL. Interpretation of results to identify conserved and variable regions and correlate them with physico-chemical and structural properties. 6. Search and retrieval: genomic data at NCBI server, Interpreting DNA and Protein microarray data. 7. Use of gene prediction methods (Genscan,/Glimmer), various primer designing and restriction site prediction tools. 8. Promoter analysis of different genes and TF binding sites. 9. Use of different protein structure prediction databases Protein data bank (PDB), SCOP Structural Classification of Protein Database (SCOP), Protein Structure Classification Database (CATH). 10. Exploring and using the derived databases: PROSITE, PRINTS, BLOCKS, Pfam and Prodom for pattern searching, domain searches, etc.). 11. Protein-protein interaction study tools. 12. Construction and study of protein structures using RASMOL/Deepview/PyMol. Homology modelling of proteins. Use of tools for mutation and analysis of protein structures. 13. Phylogenetic analysis of protein and nucleotide sequences, tree building, databases for barcoding. 14. Use of galaxy tool for DNA sequence analysis and NGS data. 15. Use of R language in data analysis.	**2 hours** **2 hours** **2 hours** **2 hours** **2 hours** **2 hours** **2 hours** **2 hours** **2 hours** **2 hours**
Pedagogy:	Internet based tools, hands on and group exercises, videos, moodle guided exercises and expert lectures.	
References/ Readings:	**Andrew Leach.** (2001). Molecular Modelling: Principles and Applications, Prentice Hall. **Antao, T.** (2018). Bioinformatics with Python Cookbook: Learn how to use modern Python bioinformatics libraries and applications to do cutting-edge research in computational biology. Packt Publishing Ltd. **Attwood, T. K., Parry-Smith, D. J. and Phukan S.** (2022). Introduction to Bioinformatics Delhi. Pearson Education (Singapore) Ptd. Ltd. **Bajorath J.** (2004) Chemoinformatics: Concepts, Methods, and Tools for Drug Discovery (Methods in Molecular Biology), Humana Press. **Baxevanis, A.D., Davison, D.B., Page, R.D.M. and Petsko, G.A.** (2004) Current Protocols in Bioinformatics by, New York, John Wiley & Sons Inc.	

Bourne Philip E. and Weissig Helge (2003). Structural Bioinformatics - Methods of biochemical Analysis V. 44. New Jersey. Wiley-Liss.

Bujnicki, J. M., Droogmans, L., Grosjean, H., Purushothaman, S. K., and Lapeyre, B. (2008). Practical Bioinformatics. Springer.

Dov Stekel, (2003) Microarray Bioinformatics; Cambridge University Press.

Fasman, G.D. (1989). Prediction of protein structure and the principles of protein conformation. New York. Plenum Press.

Friesner, R.A. Ed., Prigogine, L. Ed. and Rice, S.A. (2002). Computational methods for protein folding: Advances in chemical physics vol. 120. New York. John Wiley and sons, Inc. Publication.

Gimona, G. Cesareni and Yaffe, M. Sudol (Eds.). (2004). Modular protein domains, USA, Wiley-vch Verlag gmbh and co. 3-527-30813-X .

Gundertofte, K. and Jorgensen, F.S. (2000). Molecular modelling and prediction of bioactivity, New York. Kluwer Academic Publishers.

Mount, David. (2004). Bioinformatics: Sequence and Genome Analysis. New York, Cold Spring Harbor Laboratory Press.

Rastogi, S.C., Mediratta, N. and Rastogi. P. 4th ed (2013). Bioinformatics, methods and applications, genomics, proteomics and drug discovery, Prentice Hall of India, Pvt. Ltd., New Delhi.

Stephen Misener and Stephen Krawetz. (2004). Bioinformatics, methods and protocols, methods in molecular biology, Volume 132, Humana Press, New Jersey, Third Indian reprint

Webster, D. M. Ed. (2000). Protein structure prediction: methods and protocols, Totowa Humana Press.

Public domain database/tools/resources

- DBGET-http://www.genome.jp/dbget/
- LinkDB-http://www.genome.jp/dbget/linkdb.html
  Fgeneshttp://www.softberry.com/berry.phtml?topic=products
  GeneBuilder-http://www.itb.cnr.it/sun/webgene/
- GeneSCAN-http://genes.mit.edu/GENSCAN.html
- GRAIL-http://compbio.ornl.gov/Grail-1.3/
- CLC Free Workbench http://www.clcbio.com/index.php?id=28
  BioEditor-http://bioeditor.sdsc.edu/
- CN3D 4.1 -
  http://www.ncbi.nlm.nih.gov/Structure/CN3D/cn3d.shtml
  Protein
  Explorerhttp://www.umass.edu/microbio/chime/pe_beta/pe/protexpl/f rntdoor.htm
- Chimera-http://www.cgl.ucsf.edu/chimera/
- Yasara-http://www.yasara.comhttp://www.yasara.com)
- Ribosome builder-http://rbuilder.sourceforge.net/

	• ArrayExpress-www.ebi.ac.uk/arrayexpress/ • EPICLUST-http://ep.ebi.ac.uk/EP/	
Learning Outcomes:	1. Enable to work with computational tools and to gain practical knowledge. 2. Enable to analyse Next Generation Sequencing (NGS) raw data. 3. Would be better equipped to investigate specific contemporary biological questions.	

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SEMESTER IV

Research Specific Elective Courses

Programme: M. Sc Botany
Course Code: BOTR-504
Title of the Course: Research Methodology, Techniques and Instrumentation
No. of Credits: 4
Effective from AY: 2022-23

Prerequisites for the course:	Knowledge of computers, information technology and biochemistry.	
Objective(s):	• To impart training in literature survey, citations, scientific writing, experimental design, basic biostatistics, principles and working of various instruments.	
Content:	1. **Literature survey**: Need for literature review; research reading and discriminative reading; bibliographic collection, Literature citation; different system of citations, Journal abbreviations. **2. Computers and information technology in Research:** Computer operating system, search engines, e-journals, online publications, MS office, Webliography. 3. **Scientific Writing:** Basics and importance of scientific writing; clarity, language; scientific paper and proposals components, Title, Abstract, Introduction, Materials and Methods, Results and Discussion, Conclusion, References, Tables and Illustrations; Research article, Review Paper, Book Chapter, Presentation, Scientific posters. 4. **Research ethics and Plagiarism**: Ethics in reporting research: Data errors and plagiarism; Plagiarism Check Softwares; Direct Plagiarism; Self Plagiarism; Mosaic Plagiarism; Accidental Plagiarism; Patchwriting; Invented Sources; Paraphrasing; Fake/Misleading Citations; Incremental Plagiarism; Uncredited Paraphrasing. 5. **Intellectual Property Rights (IPR):** Protection of IPR in India; Terminology associated with IPR: patent, copyright, trademark, design, geographical indication, plant variety and farmer's rights protection, trade secrets; Bio-piracy. 6. **Experimental Designs and Biostatistics:** Basic principles of experiment, Experimental unit and sampling unit, Observation, Hypothesis, Experimental error, replicates, controls,	**3 hours** **3 hours** **3 hours** **2 hours** **2 hours** **4 hours**

	randomization, null hypothesis; Population and sample, variables, data collection sampling methods, Significance, statistical test.	
	7. **Laboratory practices and safety in laboratory**: Research Bioethics and Good Laboratory Practices, General safety measures, Chemical, Physical, and Biological hazards, spillage and waste disposal, disposal of radioactive waste, first aid and Material Safety Datasheet (MSDS).	**2 hours**
	8. **pH and buffer solutions**: SI units; Molarity and Normality; Acids and bases; Hydrogen ion concentration and pH, Dissociation of acids and bases; Buffer solutions, reaction kinetics and thermodynamics.	**4 hours**
	9. **Centrifugation Techniques**: Basic principles of sedimentation; Relative Centrifugal Force (RCF) and gravitational (g) force, Density gradient centrifugation; design and care of rotors, safety aspects in the use of centrifuges.	**3 hours**
	10. **Spectroscopic Techniques:** General principles; Radiation energy and atomic structure; Basic law of light absorption; Types of spectra and their biological usefulness. Principle, application and instrumentation of UV-VIS spectrophotometry; IR (infra-red) spectrophotometry; Spectrofluorometry, Atomic absorption spectroscopy (AAS) and flame photometry; Mass spectrometry.	**9 hours**
	11. **Chromatography Techniques**: General Principles, techniques and applications: Materials for column chromatography, adsorption, partition, molecular sieving, ion exchange and affinity chromatography. Factors influencing resolution. Column development – isocratic system and gradient solvent. Chromatogram reading, qualitative and quantitative determination of peaks.	**8 hours**
	12. **Electrophoresis Techniques**: General principles, Gel electrophoresis of nucleic acids and proteins, Native PAGE, Sodium Dodocyl Sulphate-Polyacrylamide Gel Electrophoresis (SDS–PAGE), Isoelectric focusing and its application, 2D electrophoresis, Pulsed field electrophoresis, Capillary electrophoresis, Blotting techniques: Detection, recovery and estimation.	**7 hours**
	13. **Radiobiology**: The nature of radioactivity; Atomic structure, stability and radiation; Isotopes; Types of radioactive decay; Detection and measurement of radioactivity; Applications of radioisotopes in biological sciences; Safety aspects for use of radioisotopes. Non-radioactive labelling.	**2 hours**
	14. **Molecular techniques**: Flow Cytometry, Immuno-techniques, Fluorescence Resonance Energy Transfer (FRET), Fluorescence Recovery After Photobleaching (FRAP), Yeast hybrid assay, Immunoprecipitation assay, Surface Plasmon resonance,	**8 hours**

	Proximity labelling, Electrophoretic Mobility Shift Assay (EMSA), Footprinting, Protein Crystallography, Microarray analysis, Site Directed Mutagenesis, Biosensors, Clustered Regularly Interspaced Short Palindromic Sequence/CRIPSR Associated Genes (CRISPR/Cas).	
Pedagogy:	Lecture/e-learning/Assignments/Seminars/Moodle.	
References/ Readings:	**Bailey P.L.** (1980) Analysis and ion selective electrodes 2nd Ed. Heyden, London. **Bates R.G.** (1973) Determination of pH: Theory and Practices, 2nd Ed. John Wiley, New York. **Bauman R.P.** (1981) Absorption Spectroscopy. John Wiley, New York **Becker R.S.** (1969) Theory and interpretation of fluorescence and phosphorescence, Wiley Interscience, New York. **Bell R. J.** (1973) Introductory Fourier Transform spectroscopy. Academic Press, New York. **Brech F.** (1974) Analysis in instrumentation. Vol. 6. Plenum, New York. **Colthup N.B., Daly L.H. and Wiberley S.E.** (1975) Introduction to Infra-red and Raman Spectroscopy 2nd Ed. Academic Press. New York. **Day, R.A. and Gastel, B.** (2016). How to write and publish a scientific paper, Cambridge University Press. **Dean J. and Raina T.** (1969) Flame emission and atomic absorption. Dekker, New York. **Dixon R.N.** (1965) Spectroscopy and Structure. Mathuen, London **Giddings J.C.** (2002) Principles and Theory, Dynamics of Chromatography Part I Dekker, New York. **Grob R.L.** (2004) Modern Practices of Gas Chromatography. 2nd Ed. John Wiley, New York. **Guilbault G.G.** (Ed.) (2020) Practical Fluorescence. CRC Press. **Gurumani N.** (2006). Research methodology for biological sciences. MJP Publishers, Chennai. **Gurumani N.** (2005). An Introduction to Biostatistics, MJP Publishers, Chennai. **Hames B.D. and Rickwood D.** (1998) Gel electrophoresis of Proteins: A practical approach 2nd ed. IRL Press, Oxford. **Hofmann A. and Clokie S.** (2018) Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology, Cambridge University Press. **Karp, G.** (2009). Cell and molecular biology: Concepts and experiments, 7th edition. John Wiley and Sons, USA. **Kolthoff I.M. and Elving P. J.** (1978) Treatise on analytical Chemistry, Wiley Interscience, New York. **Pesez M and Bartos J.** (1974) Colorimetric and Fluorometric Analysis of Organic Compounds and drugs, Dekker, New York.	

	Reece, R. J. (2004). Analysis of genes and genomes. John Wiley and Sons Ltd. **Sacks R.D.** (1981) Emission Spectroscopy. John Wiley, New York. **Saraswathy, N. and Ramalingam, P.** (2011) Concepts and Techniques in Genomics and Proteomics. Biohealthcare Publishing (Oxford) Limited, New York. **Sharma, B.K.** (2006) Principal of analytical chemistry, Meerut Publication, Meerut. **Simpson C.F.** (1979). Techniques in liquid chromatography, Wiley-Heyden, New York. Horvath C. HPLC Vol. I Academic Orlando. F.L. Fritz J.S., Gjerde D.T. and Pohlandt C. Ion chromatography, A. Huthig, Heidelberg **Walker, J. M. and Rapley, R.** (2008). Molecular Biomethods Handbook, Hertfordshire, UK. **Watson I.N.** (1976) Introduction to Mass spectroscopy, Raven, New York. **Willard H.F., Merritt L.L., Dean, J.A. and Settle F.A.** (1988) Instrumental Method of analysis. CBS Publishers and distribution, New Delhi **Williams D.R. and Mowthorpe D. J.** (1976) Nuclear Magnetic Resonance Spectroscopy. John Wiley, New York. **Yau W. W., Kirkland J.J. and Bly D.D.** (2009) Modern size exclusion chromatography, Wiley Interscience, New York.	
Learning Outcomes:	1. Enable to understand the basic research methodologies, instrumentation, and designs. 2. Enable to gain comprehensive knowledge of valid scientific measuring and scaling approaches along with theory of computational tools. 3. Enable to analyse and interpret qualitative and quantitative data. 4. Enable to investigate specific biological questions. 5. Enable to conceive knowledge about scientific writing and presentation of valid and credible scientific report.	

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Programme: M. Sc (Botany)
Course Code: BOTR-505
Title of the Course: Applied Phycology: Utilization and Management
Number of Credits: 4
Effective from AY: 2022-23

Prerequisites for the course:	Basic knowledge in algae.	
Objective(s):	• To impart knowledge on the commercial applications of Algae and their use in environmental management.	
Content:	1. **Mariculture:** Scientific basis and Techniques of Mariculture: *Eucheuma*, *Porphyra* and *Laminaria* technique. Rafts used in Mariculture.	**5 hours**

	2. **Seaweed cultivation in India:** Seaweed resources and their distribution in India, Promotion of seaweeds in India, Seaweed cultivation and value chain in India. Seedling production of *Gracilaria* and *Ulva*.	**2 hours**
	3. **Food and food products from Seaweeds:** *Porphyra* as food: Cultivation and economics; Food and other uses, development of cultivation methods, present and future trends. *Spirulina* as human food: Nutritional aspects. Economic and environmental aspects. Therapeutic applications, harvesting wild populations, Village scale production, Microalgal nutraceuticals and their production; Cultivated edible kelps: Edible products, kelp composition, kelp production methods and world production. Some public health aspects of microalgal products. Pheophorbide, Microbial contamination, Extraneous materials, metals, organic compounds, Maintaining sanitary quality.	**10 hours**
	4. **Commercial production and application of algae: *Hydrocolloids*:** History, Chemistry production and Application, future aspects of alginates, Carrageenans, Agars. An overview of Agarophytes and Carragenanophytes in India. **Lipids and Polyols from microalgae**: History of microalgal lipid production research, Tri-glycerol, Hydrocarbon, carotenoids, polyols. **Hydrogen production by algae:** Water splitting Role of algae in hydrogen production, principles of photosynthetic hydrogen production, Bio-photolysis of water. **Products from fossil algae:** Diatomite-industrial mineral, Calcareous algal fossils and their products algal kerogen in petroleum and coal. **Biodiesel from Microalgae:** Potential of Microalgal diesel, Micro-algal mass production (Raceway Pond and photobioreactors); Economics of microalgal biodiesel.	**14 hours**
	5. **Algae in Environmental Management:** **Algae and Agriculture:** Free living cyanobacteria and algalization, *Azolla*, Microalgal soil conditioners, Microalgal plant growth regulation, Biopesticides. Seaweed use in agriculture and horticulture. **Microalgae in liquid waste treatment and reclamation:** Biological waste treatment system, Design consideration (Algal concentration, algal productivity) Operation of integrated algal bacterial system, current application, future application (Sewage grown algae, energy system, toxin removal. **Phycoremediation:** Role of Algae in Phycoremediation; Role of physico-chemical parameters on growth and development of algae; Algal survival and pollution: Algal survival under physical and chemical stresses; Responses of algae to pollutants and heavy metal pollution; Uptake and accumulation of xenobiotic substances; Utilization of algae in pollution control; Effluent	**14 hours**

	treatment using algae; Algal biomass and its utilization; Algae as energy source, Algal biofuels; Industrial collaborations. 6. **Harmful Aspects of Algae:** **Marine dinoflagellates blooms:** Dynamics and impacts; Bloom dynamics: Initiation, growth, maintenance, Termination, Ecological and Economic impacts: Negative and Positive impacts. Harmful algal blooms in India. **Hazards of freshwater blue green algae*:*** (Cyanobacteria) Neurotoxins, Hepatotoxins, other toxins, Medicinal aspects; Human poisoning, contact dermatitis. **Marine biofouling*:*** Bacterial, Microalgal and Macroalgal biofouling, control treatments; antifouling coatings. Recent improvements in chemical control Methodology, Biological control, Non-adhesive surfaces. 7. **Future prospects of Algae:** **Algae in space:** Algae and life support systems; Algae and planetary biology, Future of algae in space. Algal Transgenics and Biotechnology. **Algae in Biotechnology:** Algae as a source of bioactive commercial pigments (chlorophylls, phycobilin, and carotenoids); Macro- and micro-algae in the field of Cosmeceuticals, Production of fatty acids (PUFA), vitamins, antioxidants from Algae; Algae as recombinant enzyme bio-factories, production of single cell proteins, Algal production and cultivation, Transgene expression in microalgae; Major algal based companies in world, Algal based commercial products in market, Algal research laboratories across the world; Use of synthetic biology in the manufacture of by-products from Algae. Bioplastics from seaweeds; Genetic engineering and development of molecular markers.	**9 hours** **6 hours**
Pedagogy:	Lectures/Tutorials/Assignments/Seminars/Visit to Research Laboratories.	
References/ Readings:	**Ahmad, A., Banat, F. and amp; Al Blooshi, H. (eds.).** (2022). Algal Biotechnology: Integrated Algal Engineering for Bioenergy, Bioremediation, and Biomedical Applications. Elsevier. **Alexander, I. and Railkin** (2004). Marine biofouling: colonization processes and defenses. CRC Press LLC. **Alexander, M.** (1999). Biodegradation and Bioremediation. Academic Press. **Ayhan Demirbas**. (2008). Biofuels: Securing the Planet's Future Energy Needs. Springer – Verlag London Limited. **Chapman, V, J. and Chapman**, D.J. (1975). The algae, 2nd Edition, Mac. Millan Publ. Inc. New York. **Craig A. Grimes., Oomman** (2008). Light, water, hydrogen: the solar generation of hydrogen by water. Springer Science + Business Media, LLC.	

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Kevin G. Sellner. (2009). Physiology, Ecology, and Toxic Properties of Marine Cyanobacteria Blooms. American Society of Limnology and Oceanography Press.

León, R., Cejudo, A. G. and Fernández, E. (Eds.). (2008). Transgenic microalgae as green cell factories (Vol. 616). Springer Science and Business Media.

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Oskar R. Zaborsky. (1998). Biohydrogen. Plenum Press, New York.

Robert Edward Lee. (1999). Phycology (*Spirulina*). Cambridge University Press.

Singh, A. and Ward, O.P. (2004) Applied Bioremediation and Phytoremediation. Springer.

	Stengel, D.B., and Connan, S. (2015). Marine algae: A source of biomass for biotechnological applications. In Natural products from marine algae (pp. 1-37). Humana Press, New York, NY.a **Tiwari B. K., Declan J. Troy. (**2015) Seaweed Sustainability Food and Non-food products Ed, Academic Press Elsevier.	
Learning Outcomes:	Enable to understand the role of algae in the field of Biotechnology, Environmental monitoring, etc.	

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Annexure II

BOTR – 601: RESEARCH METHODOLOGY (4 Credits)

(Prescribed for Ph.D. Students)

Prerequisites for the course:	Basic knowledge of Biological Sciences and Biotechnology at post-graduate level.	
Objective(s):	• To familiarize fundamental research principles, research tools, and methodologies. • To facilitate data collection, compilation, analysis, interpretation and report writing. • To conduct scientific research.	
Content:	1. **Literature collection:** Need for review of literature; Review process and bibliography; Research reading; Discriminative reading; Consulting source material; Working bibliography; index cards and reference cards. 2. **Literature citation:** Different systems of citing references; Name-year system-citation in the text; Name-year system-list of references; Citation-sequence system; Alphabet-number system; Journal abbreviations. 3. **Computers and information technology in research:** Computer operating systems; MS-office; search engines; searching e-journals; online abstracts; preparing scientific webliography; online publications; biological and taxonomic databases; basic tools of bioinformatics. 4. **Scientific Writing: Fundamentals**: Need for clarity, language; origins; definition of scientific paper; preparing title, listing authors; preparing abstract; writing materials and methods; writing results and discussion; citing references; preparing tables and illustrations; selecting scientific journals for publication; citation, citation index; writing a review paper; presenting a paper orally; preparing a scientific poster. 5. **Plagiarism**: Data errors and plagiarism; Plagiarism Check Softwares; Direct Plagiarism; Self Plagiarism; Mosaic Plagiarism; Accidental Plagiarism; Patchwriting; Invented Sources; Paraphrasing; Fake/Misleading Citations; Incremental Plagiarism; Uncredited Paraphrasing. 6. **Intellectual Property Rights:** Protection of IPR in India; Terminology associated with IPR: patent, copyright, trademark, design, geographical indication, plant variety and farmer's rights protection, trade secrets; Bio-piracy. 7. **Experimental designs:** Observation; Hypothesis and null-hypothesis; Basic principles of experiments: Experimental unit and sampling unit, experimental error, discrimination,	**2 hours** **2 hours** **4 hours** **4 hours** **3 hours** **2 hours** **4 hours**

	replication, generalization, controls, randomization, measurement and a few common experimental designs.	**4 hours**
	8. ***Basic Biostatistics:*** *Population and sample, variables in biology; data collection, classification, tabulation; sampling methods; inference about population; theoretical probability distribution; hypothesis testing, students t-test, ANOVA, correlation, regression.*	**7 hours**
	9. **Microscopy:** Compound microscope: Principle, resolving power of a microscope, working distance, useful magnification, illumination (Kohler illumination); Compound microscope-instrumentation; Light microscopes: Bright-field, dark-field, phase-contrast, differential interference contrast, fluorescence, polarization and confocal scanning microscope, Stereo-zoom microscope, micrometry. Electron microscopes: Scanning electron microscope (SEM), transmission electron microscope (TEM), scanning transmission electron microscope (STEM); microtomy and staining procedures.	**2 hours**
	10. **Photography:** Light, film, camera, operation of a camera, digital photography; image analysis.	**2 hours**
	11. **Centrifugation:** Centripetal and centrifugal forces; relative centrifugal force; factors affecting sedimentation rate; sedimentation coefficient and sedimentation constant; centrifuge, gradient media, types of centrifuges; applications of centrifugation; preparative centrifugation; analytical centrifugation.	**4 hours**
	12. **Chromatography:** General principles, techniques, and applications; Paper chromatography; Thin layer chomatography; Column chromatography; Gas chromatography; Liquid chromatography - reverse phase, HPLC, size exclusion, supercritical fluid, ion exchange, affinity and preparative liquid chromatography.	**4 hours**
	13. **Electrophoresis:** Principle and components of electrophoresis; factors affecting electrophoretic mobility, support medium, buffers, detection and assay, recording and storage, safety, types of electrophoresis and their applications: microelectrophoresis, moving boundary electrophoresis, paper electrophoresis, cellulose acetate electrophoresis, gel electrophoresis: Horizontal and vertical gel electrophoresis and their applications; Specialized electrophoretic techniques; Polyacrylamide gel electrophoresis; agarose gel electrophoresis; isoelectric focusing; two-dimensional PAGE; immunoelectrophoresis and immunofixation electrophoresis; denaturing gradient gel electrophoresis; temperature gradient gel electophoresis and capillary electrophoresis.	**4 hours**

	14. **Molecular techniques**: Flow Cytometry, Immuno-techniques, FRET (Fluorescence Resonance Energy Transfer), FRAP (Fluorescence Recovery After Photobleaching), Yeast hybrid assay, Immunoprecipitation assay, Surface Plasmon resonance, Proximity labelling, EMSA (Electrophoretic Mobility Shift Assay), Footprinting, Protein Crystallography, Microarray analysis, Site Directed Mutagenesis, Biosensors, CRISPR/Cas (Clustered Regularly Interspaced Short Palindromic Sequence/CRIPSR Associated Genes). **15. Spectroscopy:** Spectrophotometry; Beer's Law; Principles, instrumentation and applications of UV-Visible Spectrophotometer, IR (infra-red), CD (circular dichoresim) spectrophotometry; spectrofluorometry; luminometry, atomic absorption spectrophotometry, flame photometry; mass spectrophotometry; ESR (electron spin resonance) and NMR (nuclear spin resonance). 16. **Radiobiology:** The nature of radioactivity; atomic structure, stability and radiation; isotopes; types of radioactive decay, detection and measurement of radioactivity; Geiger-muller counter; Scintillation counter; Applications of radioisotopes in biological sciences; safety aspects of use of radioisotopes. 17. **Immunochemical techniques:** Antigens – natural, artificial antibodies, antigen-antibody interaction, kinetics, techniques. **18. Laboratory practices and safety:** Bio-hazardous agents; Risk Groups and bio-safety levels; Laboratory-acquired Infections; Routes of exposure; Safety Measures: access to the laboratory, personal safety; Laboratory practices: cleanliness of laboratory, basic requirements of laboratory; basic and essential bio-safety equipment, disposal of bio-hazardous waste; Additional hazards: chemical hazards, fire hazards, electrical hazards, noise, radiation hazards; Safety in genetic engineering, First aid.	**5 hours** **3 hours** **2 hours** **2 hours**
Pedagogy:	Lectures/Tutorials/Seminars /Guided exercises.	
References/ Readings:	**Gurumani N.** (2005). An Introduction to biostatistics, MJP Publishers, Chennai. **Gurumani N.** (2006). Research methodology for biological sciences. MJP Publishers, Chennai. **Gupta, B.N. and Gupta N.** (2022). Research methodology. SBPD Publications, Uttar Pradesh. **Karp, G.** (2009). Cell and molecular biology: Concepts and experiments, 7th edition. John Wiley and Sons, USA. **Kolthoff I.M. and Elving P. J.** (1978) Treatise on analytical Chemistry, Wiley Interscience, New York. **Mishra, S.B. and Alok S. (2022).** Handbook of research methodology. Educreation Publishing, New Delhi.	

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Learning Outcomes:	Able to develop an understanding of basic research methodologies, instrumentation, and designs. Gain comprehensive knowledge of valid scientific measuring and scaling approaches along with theory of computational tools. Able to analyse and interpret qualitative and quantitative data. Able to investigate specific biological questions. Able to conceive knowledge about scientific writing and presentation of valid and credible scientific report.	

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