Department of Botany

School of Basic Sciences
Central University of Punjab, Bathinda

Ph.D. Program in Botany

Batch: 2023

Department of Botany

Graduate Attributes/Program Outcome:

Ph.D. Program in Botany will

1) Develop research aptitude and desired skills to undertake challenging and new opportunities in academia and industry with reference to basic and applied fields.
2) Generate human resource to cater academia and research in higher education and research institutions.

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Ph.D. Program in Botany
Course Structure of the Program

S.No	Paper Code	Course Title	L	P	Cr
1	BOT.701	Research Methodology and Computer Applications	4	-	4
2	RPE. 751	Research and Publication Ethics	2	-	2
3	BOT.752	Teaching Assistantship	-	2	1
4	UNI. 753	Curriculum, Pedagogy, and Evaluation	1	-	1
Electives (Any one)					
5	BOT.705	Advanced Genomics	4	-	4
6	BOT.706	Advances in Stress Biology	4	-	4
7	BOT.707	Advanced Molecular Systematics	4	-	4
8	BOT.708	Basics of Plant Molecular Biology	4	-	4
9	BOT.709	Algal Biotechnology	4	-	4
10	BOT. 710	Metabolic Advances of Cyanobacteria	4	-	4
		Total	**11**	**2**	**12**

L: Lectures T: Tutorial P: Practical Cr: Credits

- ***Credits required: Minimum-12 are required to fulfill Ph.D course work requirement, student may opt for any one elective based on recommendations of the supervisor**

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Compulsory courses:

Course Title: Research Methodology and Computer Applications
Course Code BOT.701
Total Hours: 60

L	P	Credits
4	0	4

Learning Outcomes

Students will be able to:

CLO1: Critically analyse, interpret, and synthesize existing scientific knowledge based on literature review.

CLO2: Identify the knowledge gap and formulate a hypothesis and design experimental/theoretical work.

CLO3: Apply good laboratory practices and biosafety protocols.

CLO4: Apricate the crucial issues in research ethics, like responsibility for research, ethical clearance for experimental studies and scientific misconduct.

CLO5: Perform hypothesis testing on small and large data samples.

CLO6: Use correlation and linear regression methods to find a relationship and good of a fit for the given data.

CLO7: Retrieve various biological data from the appropriate databases for analysis.

CLO8: Compare protein structures and perform structure-based drug designing.

Unit/ Hours	**Content**	**Mapping with CLO**
I 15 hours	**General Principles of Research:** Meaning and importance of research, Critical thinking, Formulating hypothesis and development of research plan, Review of literature, Interpretation of results and discussion. Bibliographic index **Technical Writing:** Scientific writing, writing synopsis, Research paper, Poster preparation, oral presentations and Dissertations. Reference Management using various softwares such as Endnote, reference manager, Refworks, etc. Communication skills: defining communication; type of communication; techniques of communication, etc.	CLO1 & CLO2
II 15 hours	**Introduction and Principles of Good Lab Practices:** Good laboratory practices, Biosafety for human health and environment. Biosafety issues for using cloned genes in medicine, agriculture, industry, and eco-protection, Biological containment and physical containment, Biosafety in Clinical laboratories and biohazard management, Physical, Chemical & Biological hazards and their mitigation. Biosafety	CLO3 & CLO4

	level/category of pathogens. Biosafety level of laboratories, WHO/CDC/DBT guidelines for biosafety. **Research Ethics:** Ethical theories, Ethical considerations during research, consent. Animal handling/testing, Animal experimental models and animal ethics. Perspectives and methodology & Ethical issues of the human genome project, ICMR guidelines for biomedical and health research. Intellectual property protection (IPP) and intellectual property rights (IPR), WTO (World Trade Organization), WIPO (World Intellectual Property Organization), GATT (General Agreement on Tariff and Trade), TRIPs (Trade Related Intellectual Property Rights), TRIMS (Trade Related Investment Measures) and GATS (General Agreement on Trades in Services). Patents, Technology Development/Transfer Commercialization Related Aspects, Ethics.	
III 15 hours	**Computer Applications and Biostatistics:** Introduction to spreadsheet, presentation tools. Reference Management software. Role of Cloud computing and HPC in life science research. Introduction to Big data in biology and big data analytics. Data types and sources – variables and types. Descriptive statistics of categorical data and continuous data. Estimation of parameters – hypothesis testing: tests of significance, type I and II errors, z test, t test, analysis of variance (ANOVA), chi-square goodness-of-fit test. Regression and correlation. Statistical packages and their applications.	CLO5 & CLO6
IV 15 hours	**Bioinformatics:** Biological data: sequence, structure, gene expression, pathways and molecular interactions. Primary Sequence and structure databases. GEO, KEGG Database. Introduction to Next generation Sequencing. Proteomics: Resources & repositories. Sequence analysis: Pair-wise sequence comparison, database searching methods- BLAST, FASTA, PHI-BLAST and Multiple sequence alignment. Molecular phylogeny-building phylogenetic trees. Introduction to Protein structure, Structure comparison and visualization, Structure based protein classification: CATH and SCOP. Introduction to structure-based drug designing. Structural genomics initiatives. Deep Learning in protein structure prediction and Biomedical Image analysis.	CLO7 & CLO8

Suggested Reading:

1. Gupta, S. (2010). *Research Methodology and Statistical Techniques*. Deep & Deep Publications (P) Limited, New Delhi.
2. Kothari, C.R., Garg, G. (2019). *Research Methodology: Methods and Techniques.* 4th Edition, New Age International (p) Limited. New Delhi.
3. Sahay, Vinaya and Pradumna Singh (2009). *Encyclopedia of Research Methodology in Life Sciences.* Anmol Publications. New Delhi.
4. Kauda J. (2012). *Research Methodology: A Project Guide for University Students*. Samfunds literature Publications.
5. Dharmapalan B. (2012). *Scientific Research Methodology*. Narosa Publishing
6. Norman, G. and Streiner, D. (2014). *Biostatistics:* The Bare Essentials. 4th Edition, PMPH-USA Limited.
7. Rao, P. P., S. Sundar and Richard, J. (2009). *Introduction to Biostatistics and Research Methods.* PHI learning.
8. Christensen, L. (2007). *Experimental Methodology*. Boston: Allyn & Bacon.
9. Fleming, D. O. and Hunt, D.L. (2006). *Biological Safety: Principles and Practices*. American Society for Microbiology, USA.
10. Rockman, H. B. (2004). *Intellectual Property Law for Engineers and Scientists*. Wiley-IEEE Press, USA.
11. Shannon, T. A. (2009). *An Introduction to Bioethics*. Paulist Press, USA.
12. Vaughn, L. (2012). *Bioethics: Principles, Issues, and Cases.* 2nd Edition, Oxford University Press, UK
13. Lesk, A.M. (2019). Introduction to Bioinformatics. 5th Edition, Oxford University Press, UK.
14. Ramsden, J. (2021). Bioinformatics: An Introduction (Series: Computational Biology). 4th Edition, Springer International Publishing.
15. Mount. D.W. (2004) Bioinformatics: Sequence and Genome Analysis. 2nd Ed., CSHL Press, New York.
16.Branden, C. and J. Tooze, (1999) Introduction to Protein Structure, 2nd Ed., Garland Science, USA.

Transaction Mode:

1) Lecture
2) Demonstration
3) Seminar
4) Group discussion
5) Tutorial
6) Problem solving
7) Self-directed learning

Tools

1. LMS
2. YouTube videos
3. Related Swayam Courses
4. Podcasts

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Course Title: Research and Publication Ethics
Course Code: RPE. 751
Note: This course is offered at the university level.
Total Hours: 30

L	P	Credit
2	0	2

Learning Outcomes: Students will be able to:
CLO1: Familiarize with the ethics of research.
CLO2: Illustrate the good practices to be followed in research and publication.
CLO3: Judge the misconduct, fraud and plagiarism in research.
CLO4: Utilize various online resources and software to analyze their research output.

Unit/ Hours	Content	Mapping with CLO
I 3 hours	**Philosophy and Ethics** Introduction to Philosophy: definition, nature and scope, content, branches Ethics: definition, moral philosophy, nature of moral judgements and reactions	CLO1
II 5 hours	**Scientific Conduct** Ethics with respect to science and research Intellectual honesty and research integrity Scientific misconducts: Falsification, Fabrication, and Plagiarism (FFP) Redundant publications: duplicate and overlapping publications, salami slicing Selective reporting and misrepresentation of data	CLO1 & CLO2
III 7 hours	**Publication Ethics** Publication ethics: definition, introduction and importance Best practices/ standards setting initiatives and guidelines: COPE, WAME, etc. Conflicts of interest Publication misconduct: definition, concept, problems that lead to unethical behaviour and vice versa, types Violation of publication ethics, authorship and contributor ship Identification of publication misconduct, complaints and appeals Predatory publishers and journals	CLO2 & CLO3

IV 4 hours	**Open Access publishing** Open access publications and initiatives SHERPA/RoMEO online resource to check publisher copyright & self-archiving policies Software tool to identify predatory publication developed by SPPU Journal finder/journal suggestion tools viz. JANE, Elsevier Journal Finder, Springer, Journal Suggester etc.	CLO2
V 4 hours	**Publication Misconduct** Group Discussions: Subject-specific ethical issues, FFP, authorship; conflicts of interest; complaints and appeals: examples and fraud from India and abroad Software tools: Use of plagiarism software like Turnitin, Urkund and other open source software tools	CLO2 & CLO3
VI 7 hours	**Databases and Research Metrics** Databases: Indexing databases; Citation database: Web of Science, Scopus etc. Research Metrics: Impact Factor of journal as per Journal Citation Report, SNIP, SJR, IPP, Cite Score; Metrics: h-index, g-index, i10 index, almetrics	CLO4

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Course Title: Teaching Assistantship
Course Code: BOT.752
Total Hours: 30

L	P	Credit
0	2	1

Learning Outcomes: **Total Hours: 30**

At the end of this skill development course, the scholars shall be able to
CLO1: familiarize themselves with the pedagogical practices of effective classroom delivery and knowledge evaluation system
CLO2: manage large and small classes using appropriate pedagogical techniques for different types of content

Activities and Evaluation:

- The scholars shall attend Master degree classes of his/her supervisor to observe the various transaction modes that the supervisor follows in the classroom delivery or transaction process one period per week.
- The scholars shall be assigned one period per week under the direct supervision of his/her supervisor to teach the Master degree students adopting appropriate teaching strategy(s).
- The scholars shall be involved in examination and evaluation system of the Master degree students such as preparation of questions, conduct of examination and preparation of results under the direction of the supervisor.
- At the end of the semester, the supervisor shall conduct an examination of teaching skills learned by the scholar as per the following **evaluation criteria**:
- The scholars shall be given a topic relevant to the Master degree course of the current semester as his/her specialization to prepare lessons and deliver in the classroom before the master degree students for one hour (45 minutes teaching + 15 minutes interaction).
- The scholars shall be evaluated for a total of 50 marks comprising *content knowledge* (10 marks), *explanation and demonstration skills* (10 marks), *communication skills* (10 marks), *teaching techniques employed* (10 marks), and classroom interactions (10).

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Course Title: Curriculum, Pedagogy and Evaluation
Course Code: UNI. 753
Total Hours: 18

L	P	Credit
1	0	1

Learning outcomes:

After completion of the course, scholars shall be able to:
CLO1: analyze the principles and bases of curriculum design and development
CLO2: examine the processes involved in curriculum development
CLO3: develop the skills of adopting innovative pedagogies and conducting students' assessment
CLO4: develop curriculum of a specific course/programme

Unit/ Hours	Content	Mapping with CLO
I 4 hours	**Bases and Principles of Curriculum** Curriculum: Concept and Principles of curriculum development, Foundations of Curriculum Development. Types of Curriculum Designs- Subject centered, learner centered, experience centered and core curriculum. Designing local, national, regional and global specific curriculum. Choice Based Credit System and its implementation.	CLO1
II 4 hours	**Curriculum Development** 1. Process of Curriculum Development: Formulation of graduate attributes, course/learning outcomes, content selection, organization of content and learning experiences, transaction process. 2. Comparison among Interdisciplinary, multidisciplinary and trans-disciplinary approaches to curriculum.	CLO2
III 3 hours	**Curriculum and Pedagogy** 1. Conceptual understanding of Pedagogy. 2. Pedagogies: Peeragogy, Cybergogy and Heutagogy with special emphasis on Blended learning, Flipped learning, Dialogue, cooperative and collaborative learning. 3. Three e- techniques: Moodle, Edmodo, Google classroom.	CLO3

IV 4 hours	**Learners' Assessment** 1. Assessment Preparation: Concept, purpose, and principles of preparing objective and subjective questions. 2. Conducting Assessment: Modes of conducting assessment – offline and online; use of ICT in conducting assessments. 3. Evaluation: Formative and Summative assessments, Outcome based assessment, and scoring criteria. *Activity: Develop curriculum for a course/programme related to the research scholar's discipline.*	CLO3 & CLO4

Transaction Mode

Lecture, dialogue, peer group discussion, workshop

Evaluation criteria

There shall be an end-term evaluation of the course for 50 marks for duration of 2 hours. The course coordinator shall conduct the evaluation.

Suggested Readings

- Allyn, B., Beane, J. A., Conrad, E. P., & Samuel J. A., (1986). *Curriculum Planning and Development*. Boston: Allyn & Bacon.
- Brady, L. (1995). *Curriculum Development*. Prentice Hall: Delhi. National Council of Educational Research and Training.
- Deng, Z. (2007). Knowing the subject matter of science curriculum, *Journal of Curriculum Studies*, 39(5), 503-535. https://doi.org/10.1080/00220270701305362
- Gronlund, N. E. & Linn, R. L. (2003). *Measurement and Assessment in teaching*. Singapore: Pearson Education
- McNeil, J. D. (1990). *Curriculum: A Comprehensive Introduction*, London: Scott, Foreman/Little
- Nehru, R. S. S. (2015). *Principles of Curriculum*. New Delhi: APH Publishing Corporation.
- Oliva, P. F. (2001). *Developing the curriculum* (Fifth Ed.). New York, NY: Longman
- Stein, J. and Graham, C. (2014). *Essentials for Blended Learning: A Standards-Based Guide*. New York, NY: Routledge.

Web Resources

https://www.westernsydney.edu.au/__data/assets/pdf_file/0004/467095/Fundamentals_of_Blended_Learning.pdf

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https://www.uhd.edu/academics/university-college/centers-offices/teaching-learning-excellence/Pages/Principles-of-a-Flipped-Classroom.aspx

http://leerwegdialoog.nl/wp-content/uploads/2018/06/180621-Article-The-Basic-Principles-of-Dialogue-by-Renate-van-der-Veen-and-Olga-Plokhooij.pdf

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Elective Courses:

Course Title: Advanced Genomics
Course Code: BOT.705
Total Hours: 60

L	P	Credit
4	0	4

Course Description: The course is focused on the advancements in the area of genomics and its application in finding out the answers for complex traits and diseases. The course is divided into classroom lectures, Assignments and mutual discussions, experimental planning, presentation of recent research papers from international journals. The overall aim of the course is to develop research aptitude of the student in Genomics.

Scope of the course:
CLO1: The Students/Scholar will be expected to gain knowledge in the frontier fields of high throughput DNA sequencing and its role in finding the gene expression. This will be addressed in Unit I.
CLO2: Understand the core concepts of various DNA libraries construction and its application in frontier areas tracking down the differential gene expression and finding the metabolic pathways. This will be addressed in Unit II.
CLO3: The students will able to understand DNA marker technology and its evolution with advancement of the technology. Student will be able to demonstrate the allele and trait association. This will be addressed in Unit III.
CLO4: Students will be able to demonstrate the basics of comparative genomics. Students will understand the various DNA sequencing technologies and its application molecular mapping and trait dissection. This will be addressed in Unit IV.
Essential Background Knowledge: Advanced Genetics.

Unit/ Hours	Content	Mapping with CLO
I 18 hours	Gene expression Microarray technology, Methodology and data mining tools, Applications of microarray. Next Generation sequencing Technology, Methodology, Generation of Tissue specific data, Data mining tools, Applications of NGS.	CLO1
II 18 hours	cDNA library construction, Subtractive Library EST database generation, Transcriptomics analysis targeted via NGS, Unravelling the genetic regulatory circuits.	CLO2

III 18 hours	Molecular Markers, Generation of Molecular Markers, Molecular dissection of genetic relationships, Genetic basis of trait and trait dissection.	CLO3
IV 18 hours	Genomics and Comparative Genomics, Phenomics, Quantitative Trait Analysis and Marker assisted breeding, Molecular mapping, Genome sequencing.	CLO4

Suggested Reading:

1. Lodish, H., Berk, A., Chris, A. K., Krieger, M. (2008), Molecular Cell Biology. W.H. Freeman.
2. Bruton E. Trop. (2008), Molecular Biotechnology: Genes to Protein. J&B Publishers.
3. David P. Clark. (2010), Molecular Biology. Elsevier.
4. Benjamin A. Pierce. (2008), Genetics: A conceptual approach. Palgrave Macmillan

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Course Title: Advances in Stress Biology
Course Code: BOT. 706
Total Hours: 60

L	P	Credit
4	0	4

Course Description: The content of the course is based on the basic theoretical understanding of stresses, their occurrence and after effects, molecular mechanisms associated with tolerance to the advanced research-based implications to counter and confer stress injuries.

Scope of the course:
CLO1: The student/scholar shall be benefited with the focused course on recent advances in oxidative stress biology and its management.
CLO2: A special section is kept to familiarize the scholar with methodology used in measurement and understanding the defence strategies to confer/ counter stress in general and at molecular level, which would be relevant to the future research.
CLO3: The student/scholar shall be able to use acquired knowledge for scientific research, recognisable in national and international platform.
CLO4: Explain different types of stress with examples, various physiological mechanisms that protect the plant from environmental stress i.e. adaptation, avoidance and tolerance.

Essential Background Knowledge: Biochemistry and metabolism; Advanced Plant Physiology.

Unit/ Hours	Content	Mapping with CLO
I 15 hours	**Recent advances in Stress Biology:** Types of stresses, Stress factors and occurrence, Avoidance, acclimation and tolerance, Molecular mechanisms of Drought, Temperature, salt and heavy metals tolerance. Climate change and sustainability Perspectives: Impact and adaptation of multiple stresses. Antagonism and synergism in multiple stress tolerance, Factors supporting sustainable development, CO_2 enrichment.	CLO1
II 15 hours	**Signal transduction during stress:** Perception, Transduction and response trigger, Induction of specific gene expression, Convergence and divergence of signaling pathways, ROS signaling, Hydrogen peroxide; versatile molecule of the reactive oxygen species network. Management of stress: Secondary metabolites and stress, chemistry and functional genomics their biosynthesis and stress management.	CLO2

III 15 hours	**Oxidative stress, antioxidants and stress tolerance:** ROS/NOX and their production, DNA damage, Control mechanisms, Glutathione ascorbate pathway, Role of different antioxidants in stress management. Metabolomics of stress.	CLO3
IV 15 hours	**Gene regulation during stress:** Transcription factors involved stress tolerance, Stress proteins; Heat shock (HSP's) and cold shock proteins (dehydrins), CFB, ABRE and DREB proteins etc. **RNA biology and stress:** Cellular stress and RNA Splicing, Si, RNAi, Micro RNA their implications in oxidative stress tolerance. Genome Editing and its scope.	CLO4

Suggested Reading:

1. Ahmad, S. (1995). *Oxidative Stress and Antioxidant Defenses in Biology*. 1st Edition Springer.
2. Brown, T.A. (2010). *Gene Cloning and DNA analysis: An Introduction*. Blackwell Publishing Professional. USA.
3. Buchanan, B.B. and Gruissem, W. (2005). *Biochemistry and molecular biology of plants.* IK International Pvt. Ltd. New Delhi, India.
4. Forman, H.J. and Cadenas E. (1997). *Oxidative Stress and Signal Transduction*. 1st EditionSpringer.
5. Hensley, K. and Robert, A.F. (2009). *Methods in Biological Oxidative Stress.* 1st edition Academic Press.
6. Hopkins, W.G. (2007). *Plant Biotechnology*. Infobase Publications Inc.. USA.
7. Inze D. and Montagu M. V. (2001). *Oxidative Stress in Plants*, 1st Edition, CRC Press.
8. Nelson, D. and Cox, M.M. (2009). *Lehninger Principles of Biochemistry*. W.H. Freeman and Company, New York.
9. Primrose, S.B and Twyman, R. (2011) *Principles of Gene Manipulation and Genomics*, 8thedn. Blackwell Publishing. Society of Plant Biologists, USA
10. Sunkar, R. 2012. MicroRNAs in Plant Development and Stress Responses (Signaling and Communication in Plants). Springer Publications. New Delhi.

Transaction Mode:

1) Lecture
2) Demonstration
3) Seminar
4) Group discussion
5) Tutorial
6) Problem solving
7) Self-directed learning

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Tools

1. LMS
2. YouTube videos
3. Related Swayam Courses
4. Podcasts

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Course Title: Advanced Molecular Systematics
Course Code: BOT.707
Total Hours: 60

L	P	Credit
4	0	4

Course description: This PhD-level course is a comprehensive introduction to the theory and practice of molecular systematics, including concepts of molecular evolution, sequence analysis, computational phylogenetics, codes of taxonomy, rules of nomenclature, specimen and curation.

Scope of the course:

CLO1: This graduate-level course is suitable to students working on taxonomy, molecular systematics, phylogenetic systematics, biodiversity, DNA barcoding and allied disciplines.

CLO2: The student will be expected to have background knowledge on molecular biology, biosystematics, biodiversity, bioinformatics and computational biology.

Unit/ Hours	Content	Mapping with CLO
I 15 hours	**General Introduction to Molecular Systematics:** Evolutionary theory and Tree of Life, Tree thinking, Convergent Vs. Divergent evolution, Homologous and Analogous traits, Character states: Synapomorphy, Symplesiomorphy and Homoplasy, Types of Clades: Monophyly, Paraphyly and Polyphyly, Orthologous Vs. Paralogous Sequences, Phenetics Vs. Cladistics, DNA Barcoding, and Major Loci Used in Molecular Systematics.	CLO1 and CLO2
II 15 hours	**Molecular Evolution**: Neutral theory of molecular evolution, Models of nucleotide substitution, p-distance, poisson correction, Jukes-Cantor 69, Kimura-2-Parameter, Felsenstein 81, Hasegawa, Kishino and Yano 85, General Time Reversible (GTR), Rate heterogeneity (G), Rate Invariability (I), Model selection, Hierarchical Likelihood Ratio Test (hLRT), and locus selection.	CLO1 and CLO2
III 15 hours	**DNA Sequence Analysis:** Basics of DNA Sequencing, Base calling, Sequence Assembly and Contig construction, Consensus Sequences, Multiple Sequence Alignment, Concatenation of datasets and construction of supermatrix, Sequence annotation and deposition in Genbank, DNA Flatfiles, rDNA Secondary structure construction, and *in-silico* translation. NCBI BLAST and its	CLO1 and CLO2

	variants, Vienna RNA Package and RNAalifold, Primer design using primer BLAST, CodonCodeAligner, Geneious, and MEGA.	
IV 15 hours	**Computational Phylogenetics:** Theoretical framework of phylogenetics, Distance Vs. Discrete methods, Minimum Evolution, UPGMA, Neighbour Joining, Maximum Likelihood, Maximum Parsimony, Bayesian Inference, reconstruction of phylogeny from morphological data, Gene Tree Vs. Species tree, and lineage sorting. Morphometry using ImageJ, Specimens and Curation, Herbarium Voucher preparation, Typification, Geographical sampling design, Taxonomic literature survey, Species description, Taxonomic publication and codes, Rules of nomenclature	CLO1 and CLO2

Suggested readings:

1. Describing Species, Judith Winston, Columbia University Press,978-0231068253
1. Phylogenetic Analysis of Morphological Data (Smithsonian Series in Comparative Evolutionary Biology), John J. Wiens. Smithsonian Books, 978-1560988168
2. Phylogenetics: Theory and Practice of Phylogenetic Systematics, E. O. Wiley & Bruce S. Lieberman, Wiley-Blackwell, 978-0470905968
3. Phylogenetic Trees Made Easy: A How To Manual, Fourth Edition, Barry G. Hall, Sinauer Associates, Inc. 978-0878936069
4. Inferring Phylogenies, Joseph Felsenstein, Sinauer Associates, 978-0878931774
5. Phylogenetics (Oxford Lecture Series in Mathematics and Its Applications), Charles Semple & Mike Steel, Oxford University Press, 978-0198509424
6. Plant Systematics: A Phylogenetic Approach, Walter S. Judd, Christopher S. Campbell, Elizabeth A. Kellog, Peter F. Stevens & Michael J. Donoghue, Sinauer Associates, 978-0878934072
7. Bast, F (2013) Sequence Similarity Search, Multiple Sequence Alignment, Model Selection, Distance Matrix and Phylogeny Reconstruction. *Nature Protocol Exchange*. Nature Publishing Group. doi: 10.1038/protex.2013.065 Accessible at: http://www.nature.com/protocolexchange/protocols/2740
8. Bast, F (2015) Tutorial on Phylogenetic Inference Part-1. *Resonance* 20 (4) 360-367
9. Bast, F (2015) Tutorial on Phylogenetic Inference Part-2. *Resonance* 20 (5) 445-457
10. Tree Thinking 2015) An Introduction to Phylogenetic Biology. David Baum and Stacey Smith. Roberts and Company Publishers

Transaction Mode:

1) Lecture

2) Demonstration
3) Seminar
4) Group discussion
5) Tutorial
6) Problem solving
7) Self-directed learning

Tools

1. LMS
2. YouTube videos
3. Related Swayam Courses
4. Podcasts

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L	P	Credit
4	0	4

Course Title: Basics of Plant Molecular Biology
Course Code: BOT.708
Total Hours: 60

Course Descriptor:
This course is comprehensively disseminating the knowledge that is necessary for anyone who would like to work in plant biology with different techniques. In-fact this course helps to understand the potential roles of all techniques involved in plant molecular biology.

Scope of the Course:

CLO1: Learners will be able to use to classify, identify and analysed different biomolecules from plants using different techniques.
CLO2: The different techniques used for separation different biomolecules from another one will help to isolate them and interpret the data for research use.
CLO3: The utilization of incorporation of foreign DNA elements for amplification of a particular sequence and further use to incorporate in particular interest is the outcomes of this course.
CLO4: The utilization of antibody concept for analytical purpose and its production using plant biotechnology is another outcome.

Unit/ Hours	Content	Mapping with CLO
I 15 hours	Classification of biomolecules, primary and secondary metabolites. Isolation and separation of biomolecules, extraction and isolation of DNA, RNA and proteins, isoelectric precipitation. Photometry and spectrometry, physical laws of light absorbance and transmittance and their relationship, radiant energy source, recorder and display devices, applications.	**CLO1**
II 15 hours	Electrophoretic techniques, horizontal and vertical gel electrophoresis, PAGE, native and SDS, physical laws governing electrophoresis, electrophoretic mobility, resistance, isoelectric focusing, use of Gel-Doc in recording and interpretation of results. DNA based molecular techniques, hybridization and PCR based techniques, RAPD, AFLP, RFLP and PCR-RFLP restriction digestion and amplification, molecular characterization, RAPD and AFLP fingerprints, applications in varietal identification and taxonomy, PIC value, Shannon's diversity index.	**CLO2**

	Methods of sequencing of DNA, RNA and Proteins, Blotting techniques, Artificial synthesis of gene, complementary DNA synthesis.	
III 15 hours	Chromatographic techniques: principles and applications of HPLC, Low pressure column chromatography, Adsorption chromatography, Partition chromatography, Ion-exchange chromatography, Molecular exclusion chromatography, Affinity chromatography, Gas- liquid chromatography, Thin-layer chromatography, Hydrophobic Interaction Chromatography (HIC).	**CLO3**
IV 15 hours	Basic concepts of Gene cloning, construction of genomic and cDNA libraries, screening of genomic and cDNA libraries, physical methods of gene transfer, gene knock out, gene therapy, in-vitro mutagenesis, microarrays and DNA microchips. Immunosorbent techniques, principles, methodology and applications of ELISA in the detection and estimation of simple and conjugated proteins, storage and functional proteins, levels of solubility and clarification of proteins, Hybridoma technology and monoclonal antibodies, immunoprecipitation, immunoblotting etc.	**CLO4**

Suggested Readings:

1. Beedu Sashidhar Rao, Vijay Deshpande (2005). *Experimental Biochemtristry*. I.K. International Pvt. Ltd.
2. M. Daniel (1991). *Methods in Plant Chemistry and Economic Botany*. Kalyani Publishers.
3. Keith Wilson and John Walker (2000), *Practical biochemistry- Principles and techniques.* Cambridge University Press.
4. Avinash Upadhyay, Kakoli Upadhyay, Nirmalendu Nath (2006). *Biophysical Chemistry- Principles and Techniques*. Himalaya Publishing House.

Transaction Mode:

1) Lecture
2) Demonstration
3) Seminar
4) Group discussion
5) Tutorial
6) Problem solving
7) Self-directed learning

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Tools

1. LMS
2. YouTube videos
3. Related Swayam Courses
4. Podcasts

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L	P	Credits
4	0	4

Course Title: Algal Biotechnology
Course Code: BOT.709
Total Hours: 60

Course Descriptor:

The aim of the course is to develop research aptitude and disseminating the knowledge in students who would like to pursue research in Algal Biotechnology. The course will help to understand the applied aspects of algae with special focus on commercial scale cultivation, metabolic and genetic engineering of algae for value added products, and their commercial aspects. The course is focused on the recent advancements in the field of Algal Biotechnology, finding research gaps and challenges in the commercialization of algae-based products and technologies.

Scope of the Course:

Upon successful completion of this course, the student will be able to:
CLO1: Learn the methods and advancements of commercial-scale algae cultivation.
CLO2: Demonstrate understanding of the algae-based environmental technologies and potential role of algal systems in achieving Sustainable Development Goals.
CLO3: Demonstrate understanding of the commercial products from algae
CLO4: Demonstrate understanding of the approaches for metabolic and genetic engineering of algae for producing commercial products and technologies.
CLO5: Demonstrate understanding of techno-economic assessment, and commercialization of the value-added products from algae.

Essential Background Knowledge: Basic and advanced phycology, plant biochemistry and physiology, and plant molecular biology.

Unit/ Hours	Content	Mapping with CLO
I 15 hours	**Commercial scale algae Cultivation, Challenges and Management:** Modern techniques for microalgae cell isolation, separation and viability test, Mass cultivation of microalgae, laboratory scale to industrial scale, Indoor and outdoor cultivation systems, Commercial-scale algae cultivation systems: Bioreactors, type of photobioreactors, Raceway ponds, High-rate	CLO1

	algal ponds, Algal biofilms and consortia, Basic and advanced techniques for biomass harvesting, drying, and preservation. Challenges in Algae mass culture, abiotic and biotic factors, Grazers in algae-cultivation systems, Contamination issues and their management, Metagenomics, and its importance in algal systems.	
II 15 hours	**Environmental Management using Algal systems:** Phycoremediation technology: wastewater treatment, soil bioremediation and reclamation, remediation of contaminants of emerging concerns, and resource recovery from waste streams, Mechanisms of contaminants removal and stress tolerance in algae, Gene expression, Epigenetics and other omics approaches. Carbon fluxes, Algae-based carbon sequestration, Carbon-neutral products from algae, Algae as bioindicators, Algal blooms, Biocides and algicides.	CLO2
III 15 hours	**Value-added Products from Algae:** Primary and secondary metabolites, their commercial importance, Bioactive compounds, extraction and characterization techniques, Techniques for biochemical engineering and regulation of gene expression, bioactivity assessment, Advanced technologies and applications of algae-derived value-added products: Algal bioinoculants, Bio-stimulants. Nutraceuticals and Pharmaceuticals, Aquaculture feed supplements, Animal feed, Functional food, Bioplastics, Biofuels, Biocrude, Biochar, Green chemicals and other emerging industrial applications.	CLO3
IV 15 hours	**Recent Advances in the Commercialization of Algae-based Value-added Products:** Methods for strain improvement; Role of omics approaches for strain improvement, Advancements in the metabolic and genetic engineering of algae, Good Laboratory Practice and Biosafety, Algal-based Biorefineries and Circular Bioeconomy, Life-Cycle Assessment, Techno-economics, Algae industries.	CLO4 & CLO5

Suggested readings

1. Richmond, A. and Hu, Q., 2013. Handbook of microalgal culture: Applied Phycology and Biotechnology. John Wiley & Sons, eISBN: 9781118567166
2. Yousuf, A. ed., 2020. Microalgae Cultivation for Biofuels Production. Academic Press, ISBN: 9780128175361.

3. Alam, M.A., Xu, J.L. and Wang, Z. eds., 2020. Microalgae biotechnology for food, health, and high value products. Singapore: Springer. eISBN: 9780128241813.
4. Slocombe, S.P. and Benemann, J.R. eds., 2017. Microalgal production for biomass and high-value products. CRC Press, ISBN 9781032097923.
5. Jacob-Lopes, E., Maroneze, M.M., Queiroz, M.I. and Zepka, L.Q. eds., 2020. Handbook of microalgae-based processes and products: fundamentals and advances in energy, food, feed, fertilizer, and bioactive compounds. Academic Press. ISBN: 978-0-12-818536-0.
6. Singh, B., Bauddh, K. and Bux, F. eds., 2015. Algae and environmental sustainability (Vol. 7). India: Springer. eBook ISBN978-81-322-2641-3.
7. Bux, F. and Chisti, Y. eds., 2016. Algae biotechnology: products and processes. Springer, eISBN: 978-3-319-12334-9.
8. Nambisan, P., 2017. An introduction to ethical, safety and intellectual property rights issues in biotechnology. Academic Press.
9. El-Sheekh Mo, Abomohra Ae., eds., 2021. Handbook of Algal Biofuels, Aspects of Cultivation, Conversion, and Biorefinery. ISBN: 978-0-12-823764-9.
10. Venkataraman G.S., 1972. Algal Biofertilizers and Rice Cultivation. Today & Tomorrow's Printers & Publishers, p. 75.

Transaction Mode:

1. Lecture
2. Demonstration
3. Seminar
4. Group discussion
5. Tutorial
6. Problem solving
7. Self-directed learning

Tools

1. LMS
2. YouTube videos
3. Related Swayam Courses
4. Podcasts

Department of Botany

L	P	Credits
4	0	4

Course Title: Metabolic Advances of Cyanobacteria
Course Code: BOT.710
Total Hours: 60

Course Descriptor: –The aim of the course is to develop research aptitude and disseminating the knowledge in students who would like to pursue research in cyanobacterial metabolism. The course will help to understand the mechanism and stress regulation of cyanobacteria under extreme environmental condition. The course is focused on more elaborative strategies for engineering cyanobacteria to meet the challenges of employing cyanobacteria for large-scale industrial applications.

Scope of the Course:
Upon successful completion of this course, the student will be able to:
CLO1: Learn the different metabolic process involved in cyanobacterial metabolism.
CLO2: Learn the regulatory mechanism in cyanobacteria under abiotic stress.
CLO3: Learn the strategies for engineering cyanobacteria for large-scale industrial applications
CLO4: Demonstrate understanding of the development and progress on cyanobacterial engineering for biofuel production to inspire the future directions.

Essential Background Knowledge: Basic and advanced phycology, plant biochemistry and physiology, and plant molecular biology.

Unit/ Hours	Content	Mapping with CLO
I 15 hours	**General Introduction and Metabolic Processes in Cyanobacteria:** Introduction to cyanobacteria**, i**norganic carbon assimilation, their mechanisms, Nitrogen assimilation, oxygenic photosynthesis, electron transport system (ETS), oxygenic photosynthesis, its potential in bioproduction, cyanotoxins and their occurrence.	CLO1
II 15 hours	**Stress Acclimation in Cyanobacteria:** Introduction of different abiotic stress, Basic mechanism of salt response; inorganic ion extrusion and compatible solutes accumulation, osmotic stress and nitrate uptake, Signalling in cyanobacteria, recent progress on stress regulation**.**	CLO2
III 15 hours	**Advances in Cyanobacteria:** Overview on Growth rate, Genome editing, metabolic flux, transcriptional control, strain diversity, enzyme engineering, product toxicity, microbial consortium	CLO3

IV 15 hours	**Case study in cyanobacteria through genetic engineering**: Background and characteristics of cyanobacteria, Production of biofuel, Hydrodynamics and motility of cyanobacteria. Harvesting and extraction methods, Biofuel products and their applications.	CLO4

Suggested readings

3) Cameán, A.M. and Jos, A. eds., 2020. Cyanobacteria and Cyanotoxins: New Advances and Future Challenges.
4) Chorus, I. and Welker, M., 2021. Toxic cyanobacteria in water: a guide to their public health consequences, monitoring and management (p. 858). Taylor & Francis.
5) El-Sheekh Mo, Abomohra Ae., eds., 2021. Handbook of Algal Biofuels, Aspects of Cultivation, Conversion, and Biorefinery. ISBN: 978-0-12-823764-9.
6) Meriluoto, J., Spoof, L. and Codd, G.A. eds., 2017. *Handbook of cyanobacterial monitoring and cyanotoxin analysis*. John Wiley & Sons.
7) Metcalf, J.S. and Codd, G.A., 2012. Cyanotoxins. In Ecology of cyanobacteria II (pp. 651-675). Springer, Dordrecht.
8) Mishra, A.K., Tiwari, D.N. and Rai, A.N. eds., 2018. Cyanobacteria: From basic science to applications. Academic Press.
9) Sitther V, Tabatabai B, inventors; Morgan State University, assignee. Engineered cyanobacteria with enhanced salt tolerance. United States patent US 10,626,363. 2020 Apr 21.
10) Vijay, D., Akhtar, M.K. and Hess, W.R., 2019. Genetic and metabolic advances in the engineering of cyanobacteria. Current opinion in biotechnology, 59, pp.150-156.
11) Yousuf, A. ed., 2020. Microalgae Cultivation for Biofuels Production. Academic Press, ISBN: 9780128175361.
12) Application of Cyanobacteria (Roholtiella sp.) Liquid Extract for the Alleviation of Salt Stress in Bell Pepper (Capsicum annuum L.) Plants Grown in a Soilless System
13) Syiem, M.B., Singh, A.K. and Rai, A.N., 2009. Nitrogen metabolism in cyanobacteria. In Algal Biology and Biotechnology (p. 1081). IK, International New Delhi.
14) Bryant, D.A. ed., 2006. The molecular biology of cyanobacteria (Vol. 1). Springer Science & Business Media.

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