Master of Science in Plant Cell and Tissue Culture

Department of Plant Sciences
University of Colombo

E-Handbook

2026

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Introduction

'Plant Cell and Tissue Culture' in general, is the growth of individual plant cells or isolated tissues on a nutrient medium, under aseptic conditions in glass or plastic vessels under artificial light. Also referred to as *in vitro* culture, it is an important and essential technique used for plant regeneration and micropropagation, particularly in modern plant biotechnology, agriculture, horticulture and related industries. Applications of plant cell & tissue culture techniques include obtaining virus free plants, clonal propagation, induction of genetic variability, crop improvement through genetic engineering, production of haploids, production of secondary metabolites through cell cultures etc. From this study programme it is expected to produce experts in the field of plant cell and tissue culture. These experts in turn could use the knowledge gained in their institutes, start their own enterprises, provide training opportunities and thereby produce skilled human resources in the field and assist in developing the biotechnology industry in the country. This will in turn improve the local agriculture and horticulture industry and will lay the framework for encouraging, promoting and assisting industrial application of plant cell and tissue culture.

The Department of Plant Sciences has been conducting the Master of Science (MSc) in Plant Cell and Tissue Culture for more than two decades. The curriculum and the syllabi of the programme have been revised to accommodate the up-to-date knowledge in the field of study and to facilitate the degree holders to be conversant in skills and knowledge to respond to contemporary needs of the profession and industry.

Objectives:

The aims of this programme are,

- To enhance the capacity of graduates to advance their knowledge and research skills, and other abilities for higher degrees and to provide a post-graduate qualification
- To produce experts in the field of Plant Cell and Tissue Culture for specialized professional employment, technological capacity, or entrepreneurship
- To enhance employment opportunities in the areas of biotechnology/ agrobiotechnology, horticulture, and related research and/or training institutes
- To generate skilled human resources, thereby assisting the development of biotechnology industry in the country

Programme Intended Learning Outcomes (PLOs)

At the end of the programme students should be able to,

I. demonstrate a critical awareness of fundamental concepts, theories, processes, applications, current issues and recent developments in the field of Plant Cell and Tissue Culture

II. analyse and evaluate current research in the field of Plant Cell and Tissue Culture

III. use the practical skills efficiently and effectively and apply proper scientific method and hypothesis testing to design and conduct investigations and make accurate interpretations and conclusions

IV. construct and sustain arguments and use those appropriately in problem solving

V. communicate the findings/conclusions clearly in oral and written format to specialist as well as to the wider community

VI. apply suitable technologies and methods to plant cell/tissue culture associated industries

VII. evaluate issues, and plan and execute appropriate solutions in a methodical and creative way to deal with issues and challenges in related industries

VIII. demonstrate self-direction and originality in tackling and solving problems related to the field

IX. take initiative, assume personal responsibility and demonstrate accountability and ability to instill entrepreneurship

X. demonstrate transferable skills including ICT skills and information literacy with the capability of organizing and processing data

XI. demonstrate skills in independent learning for continuous professional development

XII. maintain ethical standards and professional conduct at all times

Programme Structure

Part I	Semester I	MTC5109	Postgraduate Diploma (SLQF L8)	Master of Science (SLQF L9)	Master of Science (Research) (SLQF L10)
		MTC5110			
		MTC5111			
		MTC5112			
		MTC5113			
		MTC5114			
		MTC5115			
		MTC5116			
	Semester II	MTC5209			
		MTC5210			
		MTC5211			
		MTC5212			
		MTC5213			
		MTC5214			
		MTC5215			
PART II	Semester III	MTC5303			
PART III	Semester IV	MTC5401			

Modules of Part I (PG Diploma)

Course code	Course title	No. of Hours	No of credits
Semester I			
MTC5109	Plant Growth and Development	15L	1
MTC5110	Plant nutrition and growth regulators	15L	1
MTC5111	Principles of plant tissue culture technology	15L	1
MTC5112	Tissue culture media and tissue culture environment	15L	1
MTC5113	Laboratory design and management	20L 20P	2
MTC5114	Molecular gene technology	30L	2
MTC5115	Biosafety, Bioethics and IPR	15L	1
MTC5116	Practical Module I	120P	4
Semester II			
MTC5209	Data analysis and computer applications in tissue culture	30L	2
MTC5210	Scientific communication	30P	1
MTC5211	Cell culture and natural products	15L	1
MTC5212	Tissue culture in crop improvement	15L	1
MTC5213	Commercial tissue culture	30L	2
MTC5214	Entrepreneurship	15L	1
MTC5215	Practical Module II	120P	4

Modules of Part II (MSc)

Course code	Course title	No. of Hours	No of credits
Semester III			
MTC5303	Directed Study	150 P	5

Modules of Part III (MSc Research)

Course code	Course title	No. of Hours	No of credits
Semester III			
MTC5401	Research Project	1 Year	30

Details of the Modules – Semester I

<table>
<tr><td>Course Code / Title</td><td colspan="4">MTC5109 / Plant Growth and Development</td></tr>
<tr><td>Credit Value</td><td colspan="4">1</td></tr>
<tr><td>Prerequisites</td><td colspan="4">None</td></tr>
<tr><td rowspan="2">Details</td><td>Lecture hours</td><td>Practical hours</td><td>Independent Learning hours</td><td>Notional hours</td></tr>
<tr><td>15</td><td>-</td><td>35</td><td>50</td></tr>
<tr><td>Rationale</td><td colspan="4">This course is designed to provide the students with an understanding of the plant physiological concepts related to plant cell and tissue culture.
Advanced topics in plant physiology will be discussed with special emphasis on signal transduction related to regulation of developmental processes and responses to environmental factors.</td></tr>
<tr><td>Intended Learning Outcomes</td><td colspan="4">At the successful completion of the course the students will be able to
• demonstrate understanding of the aspects of plant growth and development related to plant cell and tissue culture
• appraise the effects of various external factors on plant growth
• analyze how plants respond to biotic/abiotic stresses</td></tr>
<tr><td>Course Content</td><td colspan="4">Eukaryotic cell cycle and regulation; Plant embryogenesis: from embryo to adult plant; Non-zygotic embryos (somatic embryos); Plant organogenesis and regulation; Senescence and programmed cell death (PCD); Signal transduction in plants – mechanisms, plant hormone signaling; Plant water relations; Membrane transport of solutes; Carbon metabolism and signaling; External factors and plant growth (phytochrome, blue light etc); Responses to abiotic and biotic stresses; Physiological and anatomical changes in plants related to hardening.</td></tr>
<tr><td>Method/s of Evaluation:</td><td colspan="4">End of semester theory examination (70%), assignments and/or in-class assessments (30%)</td></tr>
<tr><td>References</td><td colspan="4">• Taiz, L., Zeiger, E., Møller, I. M. and Murphy, A. (2014). Plant Physiology and Development (6th Edition), Sinauer Associates, inc.
• Buchanan, B. B., Gruissem, W. and Jones, R. L. (Eds.). (2015). Biochemistry and Molecular Biology of Plants (2nd Edition), Wiley.
• Jones, R. L., Ougham, H. and Waaland, S. (2012). The Molecular Life of Plants (1st Edition), Wiley-Blackwell.
• Relevant journal articles.</td></tr>
</table>

<table>
<tr><td>Course Code / Title</td><td colspan="4">MTC5110 / Plant Nutrition and Growth Regulators</td></tr>
<tr><td>Credit Value</td><td colspan="4">1</td></tr>
<tr><td>Prerequisites</td><td colspan="4">None</td></tr>
<tr><td rowspan="2">Details</td><td>Lecture hours</td><td>Practical hours</td><td>Independent Learning hours</td><td>Notional hours</td></tr>
<tr><td>15</td><td>-</td><td>35</td><td>50</td></tr>
<tr><td>Rationale</td><td colspan="4">The course will provide knowledge and skills required to identify different mineral requirements of plants, nutritional deficiencies and disorders exhibited by plants and suggest remedial actions for maintaining plant health. It also extends knowledge on identifying the role of phytohormones and growth regulators in mediating the specific growth and development responses in plants while discussing current and future applications of them in commercial crop cultivation.</td></tr>
<tr><td>Intended Learning Outcomes</td><td colspan="4">After successful completion of this course students will be able to
• demonstrate an understanding of fundamental concepts in plant mineral nutrition
• identify the mineral deficiencies and disorders in plants
• recognize the role of plant hormones and growth regulators in growth and development of plants
• discuss the current applications of growth regulators in crop cultivation
• employ the theoretical knowledge in plant growth regulation for constructing frontier approaches to improve future crop cultivation</td></tr>
<tr><td>Course Content</td><td colspan="4">Plant nutrition: essential nutrients, deficiencies and plant disorders, biochemical functions of plant mineral nutrients, techniques in nutritional studies, treating nutritional deficiencies, soil, roots and microbes;
Plant hormones and growth regulators: regulation of plant growth and development by classical plant hormones- auxins, gibberellins, cytokinins, ethylene, abscisic acid and similar growth regulatory substances, introduction to natural growth substances with phytohormonal-like regulatory roles such as polyamines, oligosaccharins, salicylates, jasmonates, sterols, brassinosteroids, dehydrodiconiferyl alcohol glucosides, turgorins, systemin, strigolactones etc.</td></tr>
<tr><td>Method/s of Evaluation:</td><td colspan="4">End of semester theory examination (70%), assignments and/or in-class assessments (30%)</td></tr>
<tr><td>References</td><td colspan="4">• Mengel, K. and Kirkby, E. A. (2001). Principles of Plant Nutrition (5th edition), Springer.
• Taiz, L., Zeiger, E., Møller, I. M. and Murphy, A. (2014). Plant Physiology and Development (6th Edition), Sinauer Associates, inc.</td></tr>
</table>

<table>
<tr><td>Course Code / Title</td><td colspan="4">MTC5111/ Principles of Plant Tissue Culture Technology</td></tr>
<tr><td>Credit Value</td><td colspan="4">1</td></tr>
<tr><td>Prerequisites</td><td colspan="4">None</td></tr>
<tr><td rowspan="2">Details</td><td>Lecture hours</td><td>Practical hours</td><td>Independent Learning hours</td><td>Notional hours</td></tr>
<tr><td>15</td><td>-</td><td>35</td><td>50</td></tr>
<tr><td>Rationale</td><td colspan="4">This course will provide a general introduction to the exciting field of plant tissue culture technology. The fundamental concepts will be taught as a foundation for more advanced courses in the discipline.</td></tr>
<tr><td>Intended Learning Outcomes</td><td colspan="4">After successful completion of this course students will be able to
• demonstrate an understanding on basic concepts of tissue culture and recognize the fundamental importance of cellular totipotency
• describe the micropropagation techniques available for plants
• assess the advantages and limitations of different micropropagation techniques</td></tr>
<tr><td>Course Content</td><td colspan="4">Overview and history; Botanical basis for tissue culture: totipotency and regeneration pathways; Stages of micropropagation; Micropropagation techniques: meristem and shoot tip culture, nodal culture, organogenesis through callus, somatic embryogenesis; Genetic variability in tissue culture: somaclonal variations and epigenetic changes</td></tr>
<tr><td>Method/s of Evaluation:</td><td colspan="4">End of semester theory examination (70%), assignments and/or in-class assessments (30%)</td></tr>
<tr><td>References</td><td colspan="4">• Kyte, L., Kleyn, J., Scoggins, H., Bridgen, M. (2013) Plants from Test Tubes: An Introduction to Micropropagation (4th Edition- revised). Timber Press.
• Smith, R. H. (2012). Plant Tissue Culture: Techniques and Experiments (3rd edition). Academic Press.</td></tr>
</table>

<table>
<tr><td>Course Code / Title</td><td colspan="4">MTC5112/ Tissue Culture Media and Tissue Culture Environment</td></tr>
<tr><td>Credit Value</td><td colspan="4">1</td></tr>
<tr><td>Prerequisites</td><td colspan="4">None</td></tr>
<tr><td rowspan="2">Details</td><td>Lecture hours</td><td>Practical hours</td><td>Independent Learning hours</td><td>Notional hours</td></tr>
<tr><td>15</td><td>-</td><td>35</td><td>50</td></tr>
<tr><td>Rationale</td><td colspan="4">This course will provide an understanding of chemical, biological, physiological and environmental factors that contribute to successful in vitro culture systems. Methods that are used to reduce plant mortality during in vitro culture will be discussed in detail.</td></tr>
<tr><td>Intended Learning Outcomes</td><td colspan="4">After successful completion of this course students will be able to
• determine appropriate culture media for different tissue culture applications
• explain the nature of plant growth processes in the in vitro tissue culture environment
• assess different factors related to in vitro culture maintenance</td></tr>
<tr><td>Course Content</td><td colspan="4">Plant tissue culture media: basic components and supplements, plant growth regulators, preparation and storage of culture media; Aseptic techniques: sterilization methods, microbial hazards in plant tissue and cell cultures; Tissue culture environment: explant factors, incubation conditions; Plant acclimatization: in vitro environment and plant growth, in vitro and ex vitro hardening, field testing</td></tr>
<tr><td>Method/s of Evaluation:</td><td colspan="4">End of semester theory examination (70%), assignments and/or in-class assessments (30%)</td></tr>
<tr><td>References</td><td colspan="4">• Razdan, M. K. (2019) Introduction to Plant Tissue Culture (3rd edition). Oxford & IBH Publishers.
• Smith, R. H. (2012). Plant Tissue Culture: Techniques and Experiments (3rd edition). Academic Press.</td></tr>
</table>

<table>
<tr><td>Course Code / Title</td><td colspan="4">MTC5113/ Laboratory Design and Management</td></tr>
<tr><td>Credit Value</td><td colspan="4">2</td></tr>
<tr><td>Prerequisites</td><td colspan="4">None</td></tr>
<tr><td rowspan="2">Details</td><td>Lecture hours</td><td>Practical hours</td><td>Independent Learning hours</td><td>Notional hours</td></tr>
<tr><td>20</td><td>20</td><td>60</td><td>100</td></tr>
<tr><td>Rationale</td><td colspan="4">This course will provide a holistic understanding of tissue culture laboratory control, continuous improvement tools and methods, and maintenance of relevant documents, allowing students to address and manage the quality of a tissue culture laboratory effectively to achieve objectives.</td></tr>
<tr><td>Intended Learning Outcomes</td><td colspan="4">After successful completion of this course the students will be able to
• identify and assess the requirements for a tissue culture laboratory as a start-up project/ business
• design a tissue culture laboratory
• define laboratory management practices
• develop documents pertaining to laboratory activities
• identify non-conforming practices of each laboratory component and suggest corrective actions</td></tr>
<tr><td>Course Content</td><td colspan="4">General guidelines: biological risks, hazard categories; Designing a laboratory to minimize contaminations and risks; Management of tissue culture laboratories: laboratory personnel, maintenance of laboratory equipment, safe handling of chemicals, laboratory house-keeping, media checks, reference material maintenance, documentation; Cost/benefit analysis; non-conformities; Laboratory accreditation.</td></tr>
<tr><td>Method/s of Evaluation:</td><td colspan="4">End of semester theory examination (50%), assignments and/or in-class assessments (50%).</td></tr>
<tr><td>References</td><td colspan="4">• Harmening, D. M. (2020). Laboratory Management, Principles and Processes (4th edition). D.H. Publishing & Consulting Inc.</td></tr>
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<table>
<tr><td>Course Code / Title</td><td colspan="4">MTC5114/ Molecular Gene Technology</td></tr>
<tr><td>Credit Value</td><td colspan="4">2</td></tr>
<tr><td>Prerequisites</td><td colspan="4">None</td></tr>
<tr><td rowspan="2">Details</td><td>Lecture hours</td><td>Practical hours</td><td>Independent Learning hours</td><td>Notional hours</td></tr>
<tr><td>30</td><td>-</td><td>70</td><td>100</td></tr>
<tr><td>Rationale</td><td colspan="4">This course provides an in-depth coverage of key concepts of Molecular Biology providing students an understanding of the major concepts and principles underlying recombinant DNA technology.</td></tr>
<tr><td>Intended Learning Outcomes</td><td colspan="4">After successful completion of this course students will be able to
• explain genome complexity
• describe gene expression and gene regulation
• compare and contrast different types of genetic marker systems
• explain the scientific basis of genetic engineering of organisms
• discuss the advantages and limitations of genetic engineering compared to conventional breeding
• critically appraise scientific literature related to the course content</td></tr>
<tr><td>Course Content</td><td colspan="4">Organization of the genome: the structure and replication of DNA, chromosome organization, complexity of bacterial and eukaryotic genomes; Gene expression and regulation; Genetic markers: concepts of classical and molecular markers and their applications; Recombinant DNA technology: molecular cloning, transgenic technology, analysis of transformed tissues, genetically modified organisms, environmental aspects of genetic engineering; Introduction to ‘Omics’ sciences.</td></tr>
<tr><td>Method/s of Evaluation:</td><td colspan="4">End of semester theory examination (70%), assignments and/or in-class assessments (30%)</td></tr>
<tr><td>References</td><td colspan="4">• Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K. and Walter, P. (2015). Molecular Biology of the Cell (6th edition). Garland Science / W. Norton & Company (2014).
• Buchanan B. B., Gruissem W., Jones R. L. (2015). Biochemistry and molecular biology of plants. (2nd edition). Wiley-Blackwell.
• Primrose, S. B. and Twyman, R. M. (2013). Principles of Gene Manipulation and Genomics (7th edition) Wiley-Blackwell.</td></tr>
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<table>
<tr><td>Course Code / Title</td><td colspan="4">MTC5115/ Biosafety, Bioethics and Intellectual Property Rights</td></tr>
<tr><td>Credit Value</td><td colspan="4">1</td></tr>
<tr><td>Prerequisites</td><td colspan="4">None</td></tr>
<tr><td rowspan="2">Details</td><td>Lecture hours</td><td>Practical hours</td><td>Independent Learning hours</td><td>Notional hours</td></tr>
<tr><td>15</td><td>-</td><td>35</td><td>50</td></tr>
<tr><td>Rationale</td><td colspan="4">This course will introduce the basic norms of Biosafety, Bioethics, and Intellectual Property (IP) law and IP registration processes (national & international) to prepare students to meet the needs of the knowledge-based environment.</td></tr>
<tr><td>Intended Learning Outcomes</td><td colspan="4">At the successful completion of this course the students will be able to,
• evaluate the benefits and potential risks of GMOs and their release to the environment
• explain the biosafety regulations, testing of GMOs and approval process of GMOs and GMFs
• analyze and discuss ethics related issues in biotechnology
• describe types of IP and their protection locally and internationally
• explore online databases for searching patent information
• apply knowledge to draft a patent application</td></tr>
<tr><td>Course Content</td><td colspan="4">Biosafety: Introduction to biosafety; GMOs and GMFs: benefits, concerns and challenges; Environmental release of GMOs: risk assessment, management and communication; Biosafety regulations and guidelines: Cartagena protocol on biosafety and other international agreements, and national biosafety guidelines; Laboratory biosafety and good laboratory practices.
Bioethics: Introduction to bioethics, Theories and principles of bioethics, Case studies on bioethics.
Intellectual Property Rights: Basic elements of IP, underlying policy, and international IP instruments and the role of IP in innovation, Patent, Industrial design, Trademarks and Copyrights and their registration process locally and internationally, Prior art searching, Drafting patent applications</td></tr>
<tr><td>Method/s of Evaluation:</td><td colspan="4">End of semester theory examination (70%), and assignments and / or in-class assessments (30%)</td></tr>
<tr><td>References</td><td colspan="4">• Relevant official websites.
• Reviews and journal articles relevant to the subject.
• Cornish W. (2019). Intellectual Property. 9th edition. Sweet & Maxwell, London, UK.
• What is Intellectual Property - WIPO Publication – No 450(E).
• Creative expressions - WIPO Publication – No 918(E).
• Inventing the Future -WIPO Publication – No 917(E).
• Making a Mark - WIPO Publication – No 900(E).
• Looking Good -WIPO Publication – No 498(E).
• Fleming, D.O. and Hunt, D.L., 2006. Biological safety: principles and practices (No. Ed. 4). ASM Press.</td></tr>
</table>

<table>
<tr><td>Course Code / Title</td><td colspan="4">MTC5116/ Practical Module I</td></tr>
<tr><td>Credit Value</td><td colspan="4">4</td></tr>
<tr><td>Prerequisites</td><td colspan="4">MTC5109, MTC5110, MTC5111,
MTC5112, MTC5114</td></tr>
<tr><td rowspan="2">Details</td><td>Lecture hours</td><td>Practical hours</td><td>Independent Learning hours</td><td>Notional hours</td></tr>
<tr><td>-</td><td>120</td><td>80</td><td>200</td></tr>
<tr><td>Rationale</td><td colspan="4">This course intends to provide students with practical knowledge and laboratory skills related to the theory courses conducted in Semester I: MTC5109 (Plant Growth and Development), MTC5110 (Plant Nutrition and Growth Regulators), MTC5111 (Principles of Plant Tissue Culture Technology), MTC5112 (Tissue Culture Media and Tissue Culture Environment), MTC5114 (Molecular Gene Technology).</td></tr>
<tr><td>Intended Learning Outcomes</td><td colspan="4">After successful completion of this course the students will be able to,
• formulate hypotheses, conduct experiments, collect and analyze data, and present results
• describe the plant nutrient deficiency symptoms and suggest corrective measures
• recognize the effects of plant growth regulators on plant growth and development
• employ basic tissue culture techniques for mass propagation of plants
• apply molecular techniques for genetic transformation</td></tr>
<tr><td>Course Content</td><td colspan="4">Plant growth and development: Plant anatomical features relevant for Cell and tissue culture; Use of image analysis software (e.g. ImageJ) in plant physiological investigations; Plant water-relations; In-vitro stress assays Plant nutrition and growth regulators: Plant mineral nutrition & deficiency symptoms, Plant growth regulators and their effect on plant growth & development
Principles of plant tissue culture technology and Tissue culture media and tissue culture environment: Preparation and storage of plant tissue culture media, Aseptic techniques, Sterilization methods, Control of microbial contaminations, Micropropagation techniques
Molecular gene technology: DNA isolation and analysis, Agrobacterium mediated transformation, analysis of transformed tissues
Relevant field studies.</td></tr>
<tr><td>Method/s of Evaluation:</td><td colspan="4">End of semester examination (50%) and assignments and/or in-class assessments (50%)</td></tr>
<tr><td>References</td><td colspan="4">• Taiz, L., Zeiger, E., Møller, I. M. and Murphy, A. (2014). Plant Physiology and Development (6th Edition), Sinauer Associates, inc.
• Smith, R. H. (2012). Plant Tissue Culture: Techniques and Experiments (3rd edition). Academic Press.
• Harmening, D. M. (2020). Laboratory Management, Principles and Processes (4th edition). D.H. Publishing & Consulting Inc.
• Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K. and Walter, P (2015). Molecular Biology of the Cell (6th edition). Garland Science / W. Norton & Company (2014).</td></tr>
</table>

Details of the Modules – Semester II

<table>
<tr><td>Course Code / Title</td><td colspan="4">MTC5209 / Data Analysis and Computer Applications in Tissue Culture</td></tr>
<tr><td>Credit Value</td><td colspan="4">2</td></tr>
<tr><td>Prerequisites</td><td colspan="4">None</td></tr>
<tr><td rowspan="2">Details</td><td>Lecture hours</td><td>Practical hours</td><td>Independent Learning hours</td><td>Notional hours</td></tr>
<tr><td>30</td><td>-</td><td>70</td><td>100</td></tr>
<tr><td>Rationale</td><td colspan="4">This course provides theoretical knowledge to design biological experiments and analyze biological data using statistical and computational methods.</td></tr>
<tr><td>Intended Learning Outcomes</td><td colspan="4">After successful completion of the course, the students will be able to
explain the basic concepts in experimental design, statistical inference, and hypothesis testing
identify suitable experimental designs for a given study
explain the underlying principles of different data analysis
analyze data using appropriate methods and report the statistical inferences
explain basic concepts and methods in bioinformatics</td></tr>
<tr><td>Course Content</td><td colspan="4">Introduction to Statistics; Concept of experimental design; Descriptive statistics & Inferential statistics; Hypotheses testing for comparing one or two populations: t test & z test; Hypotheses testing for comparing several population means: Analysis of Variance (ANOVA) & multiple comparison tests; Hypotheses testing for associations between variables: Correlation & regression analysis; Non-parametric tests; Introduction to Bioinformatics: scope, goal and applications; Biological databases and sequence formats; Bioinformatics methods/tools: pairwise and multiple sequence alignment, phylogenetics, genome browsers, protein structure analysis, protein domain and motif analysis</td></tr>
<tr><td>Method/s of Evaluation:</td><td colspan="4">End semester theory examination (70%) and continuous assessment and/or assignments (30%)</td></tr>
<tr><td>References</td><td colspan="4">Dytham, C. (2011). Choosing and Using Statistics: A Biologist’s Guide, third ed., Wiley-Blackwell, John Wiley & Sons, Inc., Chichester, UK.
Moore, D. S., Notz, W. I., & Fligner, M. A. (2015). The Basic Practice of Statistics. W.H. Freeman.
Townend, J. (2002). Practical Statistics for Environmental and Biological Scientists. John Wiley & Sons Ltd., England.
Krane, D. E. & Raymer, M. L. (2003). Fundamental Concepts of Bioinformatics. Benjamin-Cummings.
Lesk, A. (2019). Introduction to Bioinformatics. Oxford university press.
Mount, D. W. (2004). Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor Laboratory Press.
Westhead, D. R., Parish, J. H., & Twyman, R. M. (2003). Instant Notes in Bioinformatics. Taylor & Francis.
Xiong, J. (2006). Essential Bioinformatics. Cambridge University Press.
Zvelebil, M. J., & Baum, J. O. (2007). Understanding Bioinformatics. Garland Science.</td></tr>
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<table>
<tr><td>Course Code / Title</td><td colspan="4">MTC5210 / Scientific Communication</td></tr>
<tr><td>Credit Value</td><td colspan="4">1</td></tr>
<tr><td>Prerequisites</td><td colspan="4">None</td></tr>
<tr><td rowspan="2">Details</td><td>Lecture hours</td><td>Practical hours</td><td>Independent Learning hours</td><td>Notional hours</td></tr>
<tr><td>-</td><td>30</td><td>20</td><td>50</td></tr>
<tr><td>Rationale</td><td colspan="4">The course aims to provide the students with the necessary written and verbal communication skills in reading, analyzing, writing, and disseminating information, required for scientific communications.</td></tr>
<tr><td>Intended Learning Outcomes</td><td colspan="4">After successful completion of this course students will be able to
• demonstrate understanding of scientific communication
• review and evaluate the quality of scientific literature
• apply ethical practices in scientific writing
• describe the stages of the scientific communication processes
• present scientific information using professional written and verbal communication formats</td></tr>
<tr><td>Course Content</td><td colspan="4">Scientific writing styles; Key principles in effective scientific writing; Presentation of information graphically; Review scientific information presented in professional and popular media; Compose critical essays; Sourcing information and effective citation: Organization of a manuscript to its final publication; Professional presentation of scientific results (oral and poster)</td></tr>
<tr><td>Method/s of Evaluation:</td><td colspan="4">Continuous assessments (100%)</td></tr>
<tr><td>References</td><td colspan="4">• Matthews JR, Matthews RW (2014) Successful Scientific Writing. A Step-By-Step Guide for the Biological and Medical Sciences. 4th ed. Cambridge University Press.
• Morgan SE, Reichert T, & Harrison, TR, (2001) From Numbers to Words: Reporting Statistical Results for the Social Sciences. Pearson.</td></tr>
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<table>
<tr><td>Course Code/ Title</td><td colspan="4">MTC5211 / Cell Culture and Natural Products</td></tr>
<tr><td>Credit Value</td><td colspan="4">1</td></tr>
<tr><td>Prerequisites</td><td colspan="4">None</td></tr>
<tr><td rowspan="2">Details</td><td>Lecture hours</td><td>Practical hours</td><td>Independent Learning hours</td><td>Notional hours</td></tr>
<tr><td>15</td><td>-</td><td>35</td><td>50</td></tr>
<tr><td>Rationale</td><td colspan="4">This course provides the necessary knowledge and skills in employing cell culture techniques for production of plant-based secondary compounds. Students will be able to identify basic requirements for establishing successful plant cell cultures and strategies for improving productivity. Further they will analyze the factors that determine success in scale-up production in order to propose possible bioreactor system for a commercial secondary product development.</td></tr>
<tr><td>Intended Learning Outcomes</td><td colspan="4">After successful completion of this course students will be able to
explain the methods involved in establishing cell cultures, practices for culture maintenance and techniques in evaluation of growth kinetics/viability in cell cultures
discuss the basic approach for establishing plant cell cultures for harvesting secondary metabolites
describe the strategies used for improving the secondary metabolite productivity in plant cell cultures
analyze the factors affecting successful large-scale culture establishment
propose a basic bioreactor design for a commercial cell culture system.</td></tr>
<tr><td>Course Content</td><td colspan="4">Introduction to plant cell cultures; Cell culture techniques; Evaluation of cell culture performance: cell growth kinetics and cell viability; Establishing plant cell cultures for secondary metabolites; Strategies for improving secondary metabolite production in plant cell cultures: screening for high-yielding cell lines, optimization of physicochemical parameters, methods to stimulate intracellular production, methods to increase product secretion to the medium, transformed cells for production of novel compounds; Scale-up production with bioreactors: introduction to basic design of bioreactor, optimizing factors affecting product development within bioreactors</td></tr>
<tr><td>Method/s of Evaluation:</td><td colspan="4">End of semester theory examination (70%), assignments and/or in-class assessments (30%)</td></tr>
<tr><td>References</td><td colspan="4">• Razdan, M. K. (2019) Introduction to Plant Tissue Culture (3rd edition). Oxford & IBH Publishers.
• Neumann, K-H., Kumar, A., Imani, J. (2020). Plant Cell and Tissue Culture – A Tool in Biotechnology: Basics and Application (2nd edition). Springer.</td></tr>
</table>

<table>
<tr><td>Course Code/ Title</td><td colspan="4">MTC5211 / Cell Culture and Natural Products</td></tr>
<tr><td>Credit Value</td><td colspan="4">1</td></tr>
<tr><td>Prerequisites</td><td colspan="4">None</td></tr>
<tr><td rowspan="2">Details</td><td>Lecture hours</td><td>Practical hours</td><td>Independent Learning hours</td><td>Notional hours</td></tr>
<tr><td>15</td><td>-</td><td>35</td><td>50</td></tr>
<tr><td>Rationale</td><td colspan="4">This course provides the necessary knowledge and skills in employing cell culture techniques for production of plant-based secondary compounds. Students will be able to identify basic requirements for establishing successful plant cell cultures and strategies for improving productivity. Further they will analyze the factors that determine success in scale-up production in order to propose possible bioreactor system for a commercial secondary product development.</td></tr>
<tr><td>Intended Learning Outcomes</td><td colspan="4">After successful completion of this course students will be able to
explain the methods involved in establishing cell cultures, practices for culture maintenance and techniques in evaluation of growth kinetics/viability in cell cultures
discuss the basic approach for establishing plant cell cultures for harvesting secondary metabolites
describe the strategies used for improving the secondary metabolite productivity in plant cell cultures
analyze the factors affecting successful large-scale culture establishment
propose a basic bioreactor design for a commercial cell culture system.</td></tr>
<tr><td>Course Content</td><td colspan="4">Introduction to plant cell cultures; Cell culture techniques; Evaluation of cell culture performance: cell growth kinetics and cell viability; Establishing plant cell cultures for secondary metabolites; Strategies for improving secondary metabolite production in plant cell cultures: screening for high- yielding cell lines, optimization of physicochemical parameters, methods to stimulate intracellular production, methods to increase product secretion to the medium, transformed cells for production of novel compounds; Scale-up production with bioreactors: introduction to basic design of bioreactor, optimizing factors affecting product development within bioreactors</td></tr>
<tr><td>Method/s of Evaluation:</td><td colspan="4">End of semester theory examination (70%), assignments and/or in-class assessments (30%)</td></tr>
<tr><td>References</td><td colspan="4">Razdan, M. K. (2019) Introduction to Plant Tissue Culture (3rd edition). Oxford & IBH Publishers.
Neumann, K-H., Kumar, A., Imani, J. (2020). Plant Cell and Tissue Culture – A Tool in Biotechnology: Basics and Application (2nd edition). Springer.</td></tr>
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<table>
<tr><td>Course Code / Title</td><td colspan="4">MTC5213 / Commercial Tissue Culture</td></tr>
<tr><td>Credit Value</td><td colspan="4">2</td></tr>
<tr><td>Prerequisites</td><td colspan="4">None</td></tr>
<tr><td rowspan="2">Details</td><td>Lecture hours</td><td>Practical hours</td><td>Independent Learning hours</td><td>Notional hours</td></tr>
<tr><td>30</td><td>-</td><td>70</td><td>100</td></tr>
<tr><td>Rationale</td><td colspan="4">This course will introduce basic theories and concepts of commercial tissue culture. The importance of identifying challenges, risks, opportunities and skills for maintaining a commercial tissue culture laboratory will also be emphasized.</td></tr>
<tr><td>Intended Learning Outcomes</td><td colspan="4">After successful completion of this course students will be able to
• explain concepts and theories on commercial tissue culture
• propose low-cost tissue culture methods
• demonstrate an understanding of the processes involved in producing and marketing tissue culture products
• evaluate and analyze the opportunities available for commercial tissue culture</td></tr>
<tr><td>Course Content</td><td colspan="4">Concept of commercialization; Status of commercial tissue culture in the world; Large-scale operations: continuous production, time management, hardening facilities, handling and packaging of tissue cultured plants, transportation and distribution; Export oriented tissue culture: Traceability, accreditation and certification; Tissue culture of tropical crops (fruits, vegetables, ornamentals and other crops of economic value); Low-cost tissue culture; Future prospects in commercial plant tissue culture</td></tr>
<tr><td>Method/s of Evaluation:</td><td colspan="4">End of semester theory examination (70%), and assignments and/or in-class assessments /assignments (30%)</td></tr>
<tr><td>References</td><td colspan="4">• Suttle GR (2000). Commercial laboratory production In: Trigiano R. N.; Gray D. J. (eds) Plant tissue culture concepts and laboratory exercises. CRC Press, Boca Raton, FL, pp 407 – 416.
• Ushakumari, R. and Thamodharan, G. (2015). Commercial Plant Tissue Culture and Industrial Applications. Narendra Publishing House.</td></tr>
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<table>
<tr><td>Course Code/ Title</td><td colspan="4">MTC5214 / Entrepreneurship</td></tr>
<tr><td>Credit Value</td><td colspan="4">1</td></tr>
<tr><td>Prerequisites</td><td colspan="4">None</td></tr>
<tr><td rowspan="2">Details</td><td>Lecture hours</td><td>Practical hours</td><td>Independent Learning hours</td><td>Notional hours</td></tr>
<tr><td>15</td><td>-</td><td>35</td><td>50</td></tr>
<tr><td>Rationale</td><td colspan="4">This course will provide students with the basic theories and concepts of entrepreneurship. The importance of entrepreneurship, risks, challenges, opportunities and skills that one should possess to become a successful entrepreneur will also be emphasized.</td></tr>
<tr><td>Intended Learning Outcomes</td><td colspan="4">After the successful completion of this course, the student should be able to
• demonstrate an understanding of concepts, theories, and basic knowledge on entrepreneurship
• evaluate and analyze the opportunities and associated risks in turning an idea into a functional business
• develop a business proposal</td></tr>
<tr><td>Course Content</td><td colspan="4">Introduction to entrepreneurship: definitions, concept, importance to the individual, the society and the country; Turning an idea into a functional enterprise: Identify the gaps/problems in the market, evaluate the solutions and the opportunities available at individual, group and organizational levels, SWOT analysis; Basics of finance, marketing, management, operations, strategy, leadership and law; Entrepreneurial mindset, Evolution of entrepreneurship in today’s economy; The successful entrepreneur: Key traits, interpersonal skills; Detailed analysis of a successful agricultural /tissue cultural/ biotechnological enterprise.</td></tr>
<tr><td>Method/s of Evaluation:</td><td colspan="4">End of semester examination (50%), and Assessment/Assignment (50%) focusing on development and presentation of a business plan and related activities.</td></tr>
<tr><td>References</td><td colspan="4">• Byrd, Megginso (1993). Small Business Management: An Entrepreneur’s Guidebook. McGraw-Hill, Irwin.
• Carter, Sara (2012) Enterprise and Small business. Pearson UK
• Hisrich, R.D., Peters, M.P., and Shepherd, D. (2013) Entrepreneurship, McGraw-Hill Irwin, Boston.</td></tr>
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<table>
<tr><td>Course Code/ Title</td><td colspan="4">MTC5215/ Practical Module II</td></tr>
<tr><td>Credit Value</td><td colspan="4">4</td></tr>
<tr><td>Prerequisites</td><td colspan="4">MTC5209, MTC5211,
MTC5212, MTC5213</td></tr>
<tr><td rowspan="2">Details</td><td>Lecture hours</td><td>Practical hours</td><td>Independent Learning hours</td><td>Notional hours</td></tr>
<tr><td>-</td><td>120</td><td>80</td><td>200</td></tr>
<tr><td>Rationale</td><td colspan="4">This course intends to provide students with knowledge and skills related to the practical aspects of the courses conducted in Semester II: MTC5209 (Data Analysis and Computer Applications in Tissue Culture), MTC5211 (Cell Culture and Natural Products), MTC5212 (Tissue Culture in Crop Improvement), MTC5213 (Commercial Tissue Culture).</td></tr>
<tr><td>Intended Learning Outcomes</td><td colspan="4">After successful completion of this course the students will be able to
• analyze biological data using appropriate statistical tools and report the findings
• use bioinformatics databases and tools to analyze DNA/protein sequences and protein structures
• employ basic techniques to establish & maintain plant cell cultures and to evaluate culture performance
• conduct bioassays
• illustrate the basic design of a bioreactor for scaling up of plant cell cultures.
• apply relevant tissue culture techniques for crop improvement
• apply concepts of commercialization in establishing a tissue culture- based industry</td></tr>
<tr><td>Course Content</td><td colspan="4">Data Analysis and Computer Applications in Tissue Culture: Hypotheses testing for comparing one or two populations; Analysis of Variance (ANOVA) & multiple comparison tests; Hypotheses testing for associations between variables: Correlation & regression analysis; Non-parametric tests; Exploring biological databases (e.g. GenBank, UniProt, PDB, TAIR etc); Sequence similarity searching using NCBI BLAST; Multiple sequence alignment and phylogenetic tree construction; Information retrieval from genome browsers; Protein structure analysis (RasMol and PyMOL)
Cell Culture and Natural Products: Establishment of cell suspension cultures, monitoring performance and bioassays, design of a basic bioreactor for scaling up cell cultures
Tissue Culture in Crop Improvement: Applications of plant tissue culture techniques in crop improvement: anther culture, embryo rescue and culture, protoplast isolation and culture, synthetic seeds, cryopreservation, in vitro mutant selection
Commercial Tissue Culture: Executive planning for setting up of a tissue culture industry
Relevant field studies.</td></tr>
</table>

Method/s of Evaluation:	End of semesterexamination(50%)andassignments and/or in-class assessments (50%)
References	• Dytham,C.(2011).ChoosingandUsingStatistics: A Biologist's Guide, third ed.,Wiley-Blackwell,JohnWiley&Sons, Inc., Chichester, UK. • Suttle GR(2000).Commerciallaboratoryproduction In: Trigiano R. N.; Gray D.J.(eds)Planttissueculturereconceptsand laboratory exercises. CRC Press, BocaRaton,FL,pp407–416. • Neumann,K-H.,Kumar,A.,Imani,J.(2020).Plant Cell and Tissue Culture – A ToolinBiotechnology:BasicsandApplication (2nd edition). Springer. • Trigiano,R.N.andGray,D.J.(2000).PlantTissue Culture Concepts and LaboratoryExercises(2 nd edition).CRCPress-Taylor & Francis Group. • Davey, M.R.andAnthony,P.(2010).PlantCell Culture: Essential Methods. John Wiley & Sons. • Townend,J.(2002).PracticalStatisticsforEnvironmental and Biological Scientists. John Wiley & Sons Ltd., England.

Details of the Modules – Semester III & IV

<table>
<tr><td>Course Code/ Title</td><td colspan="4">MTC5303 / Directed Study</td></tr>
<tr><td>Credit Value</td><td colspan="4">5</td></tr>
<tr><td>Prerequisites</td><td colspan="4">None</td></tr>
<tr><td rowspan="2">Details</td><td>Lecture hours</td><td>Practical hours</td><td>Independent Learning hours</td><td>Notional hours</td></tr>
<tr><td>-</td><td>300</td><td>200</td><td>500</td></tr>
<tr><td>Rationale</td><td colspan="4">This course module provides an opportunity for students to apply the knowledge and skills they have gained to answer a research question or conduct a case study to broaden their knowledge, and improve research, analytical and scientific communication skills.</td></tr>
<tr><td>Intended Learning Outcomes</td><td colspan="4">After successful completion of this course the students will be able to
• formulate research problems/hypotheses and design appropriate research methodologies to test/solve research problems/hypotheses
• analyze experimental data, and propose solutions to a scientific question
• develop organized individual work habits and interpersonal skills
• synthesize a dissertation and defend findings</td></tr>
<tr><td>Course Content</td><td colspan="4">Each student will be required to carry out a directed study (guided mini research project or case study) on a specific topic given, under the supervision of an academic staff member, and submit a dissertation.</td></tr>
<tr><td>Method/s of Evaluation:</td><td colspan="4">Evaluation will be based on the dissertation submitted (60 %), seminar presentation (30%), and a viva voce examination (10 %)</td></tr>
<tr><td>References</td><td colspan="4">• Recent scholarly articles relevant to the research topic.
• Locharoenrat, K. (2017). Research Methodologies for beginners (Available online from Science Library).</td></tr>
</table>

<table>
<tr><td>Course Code/ Title</td><td colspan="4">MTC5401 / Research Project</td></tr>
<tr><td>Credit Value</td><td colspan="4">30</td></tr>
<tr><td>Prerequisites</td><td colspan="4">None</td></tr>
<tr><td rowspan="2">Details</td><td>Lecture hours</td><td>Practical hours</td><td>Independent Learning hours</td><td>Notional hours</td></tr>
<tr><td>-</td><td>1800</td><td>1200</td><td>3000</td></tr>
<tr><td>Rationale</td><td colspan="4">This course provides an opportunity for students to apply the knowledge and skills they have gained to conduct a research project relevant to Plant Cell and Tissue Culture while broadening their knowledge, and improving research, analytical and scientific communication skills.</td></tr>
<tr><td>Intended Learning Outcomes</td><td colspan="4">After successful completion of this course the students will be able to
• critically review the scholarly articles, identify gaps in the research area
• formulate aims & objectives and develop a project proposal
• compile a literature review
• synthesize a dissertation and defend findings
• demonstrate the ability to participate in an academic/ formal discussion</td></tr>
<tr><td>Course Content</td><td colspan="4">Each student will be required to carry out a guided research project on a specific topic under the supervision of an academic staff member and submit a dissertation.</td></tr>
<tr><td>Method/s of Evaluation:</td><td colspan="4">Evaluation will be based on the project proposal and defense (seminar I) (10%), mid-year progress seminar (seminar II) (10 %), dissertation (50%), Seminar III & Viva-voce (15%) and draft manuscript (15%)</td></tr>
<tr><td>References</td><td colspan="4">• Scholarly articles relevant to the research topic</td></tr>
</table>

Course vs Programme ILOs Map

H - Highly correlated; M -Moderately correlated; L - Correlated

Course code	Course Title	ILO -I	ILO -II	ILO -III	ILO -IV	ILO -V	ILO -VI	ILO -VII	ILO -VIII	ILO -IX	ILO -X	ILO - XI	ILO -XII
MTC5109	Plant Growth and Development	H	M	H	H	M	M	M	L	L	M	L	L
MTC5110	Plant nutrition and growth regulators	H	M	M	M	M	M	M	L	L	M	L	L
MTC5111	Principles of plant tissue culture technology	H	M	M	H	M	M	H	M	M	M	M	L
MTC5112	Tissue culture media and tissue culture environment	H	M	M	H	M	M	H	M	M	M	M	L
MTC5113	Laboratory design and management	M	M	M	M	H	H	H	H	H	H	H	H
MTC5114	Molecular gene technology	H	M	M	M	M	M	M	L	L	M	M	M
MTC5115	Biosafety, Bioethics and IPR	H	L	L	H	M	L	M	H	H	M	H	H
MTC5116	Practical Module I	H	H	H	H	H	H	H	H	H	H	M	H
MTC5209	Data analysis and computer applications in tissue culture	H	H	H	H	H	M	M	M	L	L	M	M
MTC5210	Scientific communication	M	H	M	M	H	M	L	L	M	H	H	H
MTC5211	Cell culture and natural products	H	M	M	H	M	M	H	M	M	M	M	L
MTC5212	Tissue culture in crop improvement	H	M	M	H	M	M	H	M	M	M	M	L
MTC5213	Commercial tissue culture	M	H	M	M	H	H	H	H	H	H	H	H
MTC5214	Entrepreneurship	M	H	M	M	H	H	H	H	H	H	H	H
MTC5215	Practical Module II	H	H	H	H	H	H	H	H	H	H	H	H
MTC5303	Directed Study	H	H	H	H	H	H	H	H	H	H	H	H
MTC5401	Research Project	H	H	H	H	H	H	H	H	H	H	H	H

Course modules vs Level Descriptors Learning Outcomes for SLQF Level 10

H - Highly correlated; M - Moderately correlated; L - Correlated

Course code	Course Title	Level Descriptors Learning Outcomes for SLQF Level 10											
		1	2	3	4	5	6	7	8	9	10	11	12
		Subject / Theoretical Knowledge	Practical Knowledge and Application	Communication	Teamwork and Leadership	Creativity and Problem Solving	Managerial and Entrepreneurship	Information Usage and Management	Networking and Social Skills	Adaptability and Flexibility	Attitudes, Values and Professionalism	Vision for Life	Updating Self / Lifelong Learning
MTC5109	Plant Growth and Development	H	M	M	M	L		M		L	M		H
MTC5110	Plant nutrition and growth regulators	H	M	M	M	L		M	M	L	L	M	H
MTC5111	Principles of plant tissue culture technology	H	M	M	M	H		M	M	M	M	M	H
MTC5112	Tissue culture media and tissue culture environment	H	M	M	M	H		M	M	M	M	M	H
MTC5113	Laboratory design and management	M	M	H	H	H	H	H	H	H	H	H	H
MTC5114	Molecular gene technology	H	M	M	M	L		M	M	L	M	M	H
MTC5115	Biosafety, Bioethics and IPR	H	M	M	M	L	M	H	M	H	H	H	H
MTC5116	Practical Module I	M	H	H	H	H		M	H	M	M	M	H
MTC5209	Data analysis and computer applications in tissue culture	H	H	M	M	M		H	M	L	M	M	M
MTC5210	Scientific communication	M	M	H	H	H	M	H	H	M	H	H	H
MTC5211	Cell culture and natural products	H	M	M	M	H		M	M	M	M	M	H
MTC5212	Tissue culture in crop improvement	H	M	M	M	H		M	M	M	M	M	H
MTC5213	Commercial tissue culture	M	M	H	H	H	H	H	H	H	H	H	H
MTC5214	Entrepreneurship	M	H	H	H	H	H	H	H	H	H	H	H
MTC5215	Practical Module II	M	H	H	H	H	H	M	H	H	H	H	H
MTC5303	Directed Study	H	H	H	H	H	L	H	M	H	H	H	H
MTC5401	Research Project	H	H	H	H	H	M	H	H	H	H	H	H

Key Contacts

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