Institute of Microbiology and Molecular Genetics
Faculty of Life Sciences
University of the Punjab, Lahore
Course Outline

Programme	BS	Course Code	MMG415	Credit Hours	3(2+1)
Course Title	**ADVANCES IN MICROSCOPE TECHNOLOGY**				

COURSE INTRODUCTION

Microscopy is a core technique in microbiology. Proper use of a microscope is vital for a microbiologist. This course is hands-on training for properly using different microscopes and further analyzing generated images using software.

LEARNING OUTCOMES

On the completion of the course, the students will:

1. be able to identify different parts of a microscope with their functions
2. be able to properly use different types of microscopes
3. be familiar with all options in ImageJ software
4. able to process and analyze digital images as needed

COURSE CONTENT

Introduction to Microscopes, Parts and Functioning of Microscope, Measurement by Microscope (Micrometry), Stereo-microscopy, Fluorescent microscopy, Confocal Laser Scanning Microscopy Introduction Digital Image / Image Analysis, Introduction to ImageJ, Size measurement in ImageJ, Particles counting in ImageJ, Intensity measurement in ImageJ, Color analysis in digital images, Analysis of fluorescent images, Analysis of stacked images

PRACTICALS

1. Students will collect samples, prepare slides and observe under microscopes
2. Measure size of different objects using micrometry.
3. Prepare slides and observe under fluorescent microscope
4. Students will perform the image processing tasks on a variety of images

TEXTBOOKS AND READING MATERIAL

1. Broeke, J., Mateos, P. J. M., & Pascau, J. 2015. *Image processing with ImageJ: Extract and analyze data from complex images with ImageJ, the world's leading image processing tool. Birmingham: Packt Publ.*
2. Resources available on https://imagej.net/ij/docs/examples/
3. Resources available on https://imagej.nih.gov/ij/index.html
4. Sanderson, J. B. (2019). Understanding light microscopy. John Wiley & Sons., USA
5. Zhang, Y. (2017). *Image Processing*. De Gruyter, USA.

ASSESSMENT			
Sr. No.	**Elements**	**Weightage**	**Details**
1.	Midterm Assessment	35%	Written Assessment at the mid-point of the semester.
2.	Formative Assessment	25%	Continuous assessment includes Classroom participation, assignments, presentations, viva voce, attitude and behavior, hands-on activities, short tests, projects, practicals, quizzes etc.
3.	Final Assessment	40%	Written Examination at the end of the semester. It will be in the form of a test to assess the student's understanding of basic statistical concepts and their application in real situation.

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Course Outline

Programme	BS	Course Code	MMG416	Credit Hours	3(2+1)
Course Title	**BIODEGRADATION AND BIOREMEDIATION**				

COURSE INTRODUCTION

Bioremediation and biodegradation are revolutionary approaches to environmental cleanup, utilizing living organisms and their enzymes to transform pollutants into harmless substances. This course delves into the principles, applications, and latest advancements in bioremediation and biodegradation, empowering you to tackle complex environmental challenges.

LEARNING OUTCOMES

On the completion of the course, the students will be able to:

1. Understand the fundamental principles of bioremediation and biodegradation.
2. Describe the types of bioremediations (in situ, ex-situ, biostimulation) and biodegradation (aerobic, anaerobic, co-metabolic).
3. Explain the role of microorganisms and enzymes in bioremediation and biodegradation.
4. Apply biodegradation and bioremediation principles to develop sustainable solutions for waste management.

COURSE CONTENT

Introduction to Bioremediation and Biodegradation: Definition and overview of bioremediation and biodegradation, Principles of Bioremediation: Biological processes involved in bioremediation, Types of bioremediation: in situ, ex-situ, and biostimulation, Factors affecting bioremediation: pH, temperature, oxygen levels, and nutrient availability Biodegradation Processes: Types of biodegradation: aerobic, anaerobic, and cometabolic, Factors affecting biodegradation: microbial communities, substrate availability, and environmental conditions, Bioremediation of Organic and inorganic Pollutants: case studies, bioremediation of heavy metals, radionuclides, and other inorganic contaminants. Biodegradation of Xenobiotics: Microbial interactions and synergies in bioremediation: Bioremediation Technologies and Applications: Bioreactors, biofilters, and biostimulation technologies, Applications in soil, groundwater, and surface water remediation, Monitoring and Assessment of Bioremediation: Monitoring parameters and analytical techniques, Assessment of bioremediation effectiveness and sustainability

PRACTICALS

1. Soil Sampling and Analysis: Collect soil samples from contaminated sites and analyze for pH, nutrient content, and microbial populations.
2. Bioreactor Setup: Design and set up bioreactors for bioremediation of heavy metal pollutants
3. Phytoremediation Experiment: Investigate the ability of plants to remove pollutants from soil.
4. Enzyme Assays: Measure any one enzyme activity involved in biodegradation (e.g., peroxidase).
5. Microbial Degradation of Pollutants: Investigate the ability of microorganisms to degrade specific pollutants (e.g., plastics, pesticides).

6. Biodegradation Kinetics: Study the kinetics of biodegradation reactions.
7. Anaerobic Biodegradation: Investigate biodegradation processes under anaerobic conditions.
8. Field Visits: Visit contaminated sites (e.g., industrial sites, landfills) to observe bioremediation and biodegradation processes in action.
9. Visit bioremediation facilities (e.g., bioreactors, phytoremediation sites) to understand large-scale bioremediation processes.

Computer Simulations: Model bioremediation and biodegradation processes using computer simulations (e.g., MATLAB).

1. Bennet, J. W., & Lemke, P. A. (2017). *Biodegradation and bioremediation*. Elsevier.
2. Das, S., & Dash, H. R. (2017). *Bioremediation and biodegradation: Mechanisms and applications.* Springer.
3. Jorgensen, K. S., & Pollard, S. J. T. (2017). *Bioremediation of contaminated soil and groundwater.* Springer
4. Khalladi, R., Benhabiles, O., & Bentahar, F. (2017). *Bioremediation and biodegradation of pollutants*. IGI Global.
5. Coelho, L. M., Rezende, H. C., Coelho, L. M., Sousa, P. A. R., Melo, D. F. O., & Coelho, N. M. M. (2020*). Advances in bioremediation of wastewater and polluted soil*. Elsevier.
6. Shah, M. P. (2020). *Microbial bioremediation and biodegradation*. Elsevier.

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Course Outline

Programme	BS	Course Code	MMG417	Credit Hours	3(2+1)
Course Title	**Oncology**				

COURSE INTRODUCTION

This course provides an overview of oncology, focusing on the biological basis of cancer, the various types of cancers, methods of diagnosis, treatment options, and current research trends. Students will gain a foundational understanding of how cancers develop, how they are diagnosed and treated, and the impact of cancer on patients and society.

LEARNING OUTCOMES

On the completion of the course, the students will:

1. Describe the basic biology of cancer, including the roles of oncogenes and tumor suppressor genes.
2. Identify different types of cancers and their unique risk factors.
3. Explain methods for cancer diagnosis, including imaging techniques and molecular diagnostics.
4. Analyze cancer treatment modalities, including surgery, chemotherapy, and immunotherapy.

COURSE CONTENT

This course will cover the basic biology of cancer, including the cell cycle, genetic mutations, and the roles of oncogenes and tumor suppressor genes. Students will learn to identify different types of cancers and understand their unique characteristics and risk factors. The course will explain various methods used for cancer diagnosis, including imaging techniques, biopsy procedures, and molecular diagnostics, while discussing the significance and applications of tumor biomarkers in cancer diagnosis and treatment. Students will analyze different cancer treatment modalities, such as surgery, radiation, chemotherapy, targeted therapy, and immunotherapy. They will also understand the causes of cancer, including environmental, genetic, and infectious factors, and assess the epidemiology of cancer globally and in Pakistan, recognizing common cancers and associated risk factors in the region. Additionally, the course will explore current trends and advancements in cancer research and clinical trials, examine the psychosocial and economic impacts of cancer on patients and their families, and address the ethical issues involved in oncology.

PRACTICALS

Visiting nearby cancer labs and hospitals, creating cancer graphs and epidemiology maps on https://gco.iarc.fr/, performing cell-based assays (MTT assay, Scratch Wound Assay, and 2D/3D cell cultures), conducting a survey on cancer awareness, and organizing a cancer awareness campaign.

TEXTBOOKS AND READING MATERIAL

1. Weinberg, R. A. (2013). *Biology of Cancer,* 2nd Edition. Garland Science, New York, United States.
2. International Agency for Research on Cancer (2024). *Cancer Epidemiology*. Retrieved from https://gco.iarc.fr/

3. National Cancer Institute (2024). Cancer Myths and Facts. Retrieved from https://www.cancer.gov/about-cancer/causes-prevention/risk/myths
4. National Cancer Institute (2024). Cancer Risk Factors. Retrieved from https://www.cancer.gov/about-cancer/causes-prevention/risk
5. National Cancer Institute (2024). Cancer Prevention. Retrieved from https://www.cancer.gov/about-cancer/causes-prevention/patient-prevention-overview-pdq
6. American Society of Clinical Oncology (2024). Steps in Cancer Drug Discovery. Retrieved from https://www.cancer.net/research-and-advocacy/introduction-cancer-research/how-are-cancer-drugs-discovered-and-developed
7. National Cancer Institute (2024). Tumor Grade and Stage. Retrieved from https://www.cancer.gov/about-cancer/diagnosis-staging/prognosis/tumor-grade-fact-sheet
8. National Cancer Institute (2024). Tumor Biomarkers. Retrieved from https://www.cancer.gov/about-cancer/diagnosis-staging/diagnosis/tumor-markers-fact-sheet

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Course Outline

Programme	BS	Course Code	MMG418	Credit Hours	3(3+0)
Course Title	**EPIGENETICS**				

Course Introduction

The course on epigenetics aims to introduce how heritable changes in gene function occur without a change in the underlying DNA sequence. Further it will also explain how changes can affect and how genes are expressed and interpreted by cells, leading to variations in traits and diseases.

Learning Outcomes

On the completion of the course, the students will be able to:

1. Understand epigenetic mechanisms and their role in gene regulation.
2. Explain how epigenetics influences development, disease, and inheritance.
3. Analyze epigenetic data and research findings.
4. Apply epigenetic principles to real-world problems.
5. Stay up-to-date with cutting-edge epigenetics research and applications

COURSE CONTENT

Introduction to Epigenetics: Definition and history of epigenetics, DNA Methylation: DNA methylation mechanisms and enzymes, Gene silencing and activation by DNA methylation, Role of DNA methylation in development, cancer, and neurological disorders, Histone Modification: Histone structure and function, Histone modification types: acetylation, methylation, phosphorylation, Chromatin remodeling, and histone modification, Chromatin Remodeling: Chromatin structure and dynamics, Chromatin remodeling complexes and mechanisms, Role of chromatin remodeling in gene expression and cellular processes. Epigenetic Regulation of Gene Expression: Transcriptional regulation by epigenetic mechanisms, Role of epigenetics in cellular differentiation and development, Epigenetic regulation of stem cell maintenance and differentiation, Epigenetics and Disease: Epigenetic alterations in cancer, neurological disorders, and metabolic diseases, Epigenetic biomarkers for disease diagnosis and prognosis, Therapeutic targeting of epigenetic mechanisms, Epigenetic Inheritance and Environmental Interactions: Epigenetic inheritance: mechanisms and implications, Environmental influences on epigenetic marks and gene expression, Epigenetic responses to stress and environmental toxins, Epigenomics and Bioinformatics: Epigenomic technologies: ChIP-seq, bisulfite sequencing, ATAC-seq, Bioinformatics tools for epigenomic data analysis, Integrating epigenomics with genomics and transcriptomics, Epigenetic editing: CRISPR-Cas9 and beyond, Epigenetic therapies: current and future directions, Epigenetics and synthetic biology.

TEXTBOOKS AND READING MATERIAL

1. Jaenisch, R., & Bird, A. (2017). *Epigenetic regulation of gene expression: Mechanisms and functions.* Springer.
2. Paro,R., Grossniklaus, U., Santoro, R., Wutz, A.,(2021). I*ntroduction to Epigenetics*. Springer.
3. Kalkan, R., (2023). *Cancer Epigenetics*. Springer Cham.
4. Allis, C.D, Jenuwein ,T. (2016). *The Molecular Hallmarks of Epigenetic Control*. National Rev Genet. 2016 Aug;17(8):487-500. doi: 10.1038/nrg.2016.59
5. Tollefsbol, t.o., (2022). *Handbook of Epigenetics: The New Molecular and Medical Genetics.* Academic press.

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Course Outline

Programme	BS	Course Code	MMG	Credit Hours	3(2+1)
Course Title	MOLECULAR MECHANISMS OF GENE EXPRESSION				

COURSE INTRODUCTION

Molecular mechanisms of gene expression is a lecture cum discussion based course that provides in-depth and conversant exposure of gene expression and its regulation. Lectures are aligned on the principles of regulating gene expression in eukaryotic cells. Moreover, the course covers molecular mechanisms of the key gene expression events including transcription, RNA processing, mRNA localization, translation and degradation. Likewise, the macromolecule structures and functions in gene expression and regulation are also included. Applications of these principles in translational medicine and therapeutics such as aging, cancer biology and drug design are also discussed.

LEARNING OUTCOMES

On the completion of the course, the students will:

1. Understand the molecular mechanisms of the key gene expression events in eukaryotic cells
2. Use of cell biology and biochemistry knowledge to explore interdisciplinary research on gene expression
3. Comprehend the numerous roles of RNA in gene expression
4. Gain awareness of gene expression in therapeutics including drug design

COURSE CONTENT

Tissue-specific expression of proteins and messenger RNAs: Specific methods for studying the protein composition of tissues, General methods for studying the protein composition of tissues, Specific methods for studying the mRNAs expressed in different tissues, General methods for studying the mRNAs expressed in different tissues. The DNA of different cell types is similar in both amount and type: DNA loss, DNA amplification, DNA rearrangement, Gene expression: Levels of gene regulation, Transcription, RNA polymerase and its types, Post transcriptional events. Regulation at transcription: Evidence for transcriptional regulation, Regulation at transcriptional elongation, Post-transcriptional regulation: Regulation after transcription, Regulation of RNA splicing, RNA editing, Regulation of RNA transport, Regulation of RNA stability, Regulation of translation, Inhibition of gene expression by small RNAs. Gene regulation and human disease: Proto-oncogenes, Elevated expression of oncogenes, Transcription factors as oncogenes, Anti-oncogenes, Oncogenes/anti-oncogenes: the relationship of cancer and normal cellular function, Gene regulation and therapy of human diseases.

PRACTICALS

Isolation of bacterial genomic DNA, Isolation of Plasmid DNA, Quantification of DNA, Isolation of DNA from various human samples like blood, hair, urine, saliva and nail. Isolation of RNA from blood cells, Quantification of RNA, Polymerase chain reactions (PCR) for various bacterial and human genes.

TEXTBOOKS AND READING MATERIAL

1. Latchman, D. (2015). *Gene Control* (2nd ed.). Garland Science. https://doi.org/10.1201/9781317407751.

2. Latchman, D. (2005). *Gene Regulation* (5th ed.). Taylor & Francis. https://doi.org/10.4324/9780203016336.

3. Sonenberg,N. 2001.*Translational Control of Gene Expression*, Cold Spring Harbor Laboratory, U.S.A.

4. Elgin,S. C. R.and Workman,J. L. 2001. *Chromatin Structure and Gene Expression,* 2nd edition, Oxford University Press, U.K.

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