COURSE OF STUDIES

for

Master of Philosophy

in

<MLS in Molecular Pathology & Cytogenetics>

UNIVERSITY OF HEALTH SCIENCES, LAHORE PAKISTAN

Program Rationale:

Medical Laboratory Sciences (MLS) comprise the study of scientific principles underlying the disciplines practiced in diagnostic and medical research laboratories (Chemical Pathology, Cytotechnology, Histotechnology, Haematotechnology, Immunology, microbiology, Molecular pathology, Cytogenetics and Forensic Science).

It is a program designed for graduates in Medical Laboratory Technology to acquire more advanced and specialized training in different specialties of a diagnostic clinical laboratory. Medical Laboratory Technologists are professionals who have the technical expertise necessary to perform a wide variety of routine and specialized tests on patient specimens to help the physician in the diagnosis and treatment of disease. These professionals practice in hospital laboratories, private medical laboratories, public health laboratories, government laboratories, research and educational institutions.

The curriculum is based on the belief that a well-trained Medical Laboratory Technologist is an asset to the health care team, and therefore, needs to be equipped with the required knowledge and skills to ensure accurate and safe diagnostic approach, in addition to having an interest in active research in prevention, cause and treatment of diseases.

Mission Statement:

It is the mission of Institute of Biomedical & Allied Health Sciences to help students develop specialized knowledge, skill, attitude and clinical judgment required for competency as medical laboratory technologists and laboratory scientists in different fields of laboratory medicine. MPhil in medical laboratory sciences program strives to prepare graduates who, using the newest methodologies, state of the art automated analyzers, critical thinking and task management, provide valid, accurate and precise test results used in the detection, diagnosis and treatment of the diseases.

Program Educational Objectives:

- To provide advanced and specific training to students in different specialties of laboratory sciences/medicine

- To provide the students a capacity to recognize the clinical significance of the test they perform, and evaluate the reliability of the results by applying quality standards
- To enable students to report results accurately using verbal and written means, recognizing the necessity to draw attention to abnormal values
- To train students in the operation of laboratory instruments and relevant troubleshooting
- To make the students capable of functioning as informed professionals in a changing health care system and have the ability to evaluate and construct their own approach to medical laboratory science practice
- To train the students in biomedical research methodology, search for biomedical science literature, interpretation of research data and in the written and oral presentation of scientific research.
- To enable students to possess good understanding of current and future health issues, public health policy and international health rules and regulations.

SCHEME OF STUDIES (2-Year)

MLS Molecular Pathology & Cytogenetics

Semester #	Course code	Course title	Credit hours		
			Theory	Practical	Total
1		Biostatistics and Research Methodology	2	0	2
	IAHS101	English (Communication Skills)	2	0	7
	IAHS102	Molecular Biology	2	1	
	IAHS104	Basic Laboratory Techniques	2	0	
	IAHS106	Laboratory Management	3	0	3
2	IAHS110	Molecular pathology and diagnostics	2	1	10
	IAHS115	Cytogenetics	2	1	
	IAHS116	Biosafety and Bioethics	2	0	
	IAHSE201	Elective Course	2	0	2
3	Research (thesis)		6		6
4	Professional & Teaching Skills Apprenticeship (PTSA)		0		2
			(Total: 30)		

DETAIL OF MAJOR COURSES

(Molecular Pathology & Cytogenetics)

MOLECULAR BIOLOGY

Credit Hrs 2+1

Objectives

- To understand core concepts of molecular biology
- To understand the molecular techniques for practical applications

Learning Outcomes

- Be able to describe the molecular biology concepts
- Be able to explain the basic and advanced techniques of molecular biology
- Be able to understand the applied aspects of molecular biology in health sciences

Course Contents

- **Introduction to Molecular Biology**
- **Organization of Genome**
- **Nucleic Acid**
    - DNA structure and replication
    - DNA mutations and repair mechanisms
    - RNA structure and types
- **Central Dogma of Molecular Biology**
    - RNA transcription and gene expression
    - Regulation of transcription
    - Translation and post-translational modifications
    - Epigenetics
- **Common Techniques in Molecular Biology**
    - Nucleic acid extraction methods
        - DNA isolation
            - Sample preparation (microorganisms, cells and tissue)
            - Organic and inorganic isolation methods
        - RNA Isolation
            - Total and PolyA (messenger) RNA extraction
        - Quality and Quantity measurement of Nucleic Acid
        - Electrophoresis

- Spectrophotometry
- Analysis and Characterization of Nucleic Acids and Proteins
- Restriction enzyme mapping
- Hybridization methods
  - Southern Blots
  - Northern Blots
  - Western Blots
- Probes
  - DNA, RNA and Protein probes, labelling and hybridization conditions
  - Detection systems and interpretation of results
- Array based hybridization
  - Genome array technologies
  - Microarrays
- **Nucleic acid amplification**
  - Polymerase Chain Reaction and Thermal Cyclers
  - Optimizing of PCR cycling conditions
- **Advances in PCR and their applications**
  - Gradient, Nested, Reverse Transcriptase and Multiplex PCR
  - Rapid Amplification of cDNA ends (RACE)
  - Restriction Fragment Length Polymorphism (RFLP)
  - Allele Specific PCR
  - Amplification-Refractory Mutation System (ARMS)
- **Real-Time PCR**
  - Principle of Real-Time PCR
  - Fluorescent chemistries for amplification detection
    - DNA Binding dyes (SYBR Green I), design and optimization
    - Fluorescent Primer/probe based chemistries (TaqMan Probes), design and optimization
  - Analysis of Real-Time PCR data
    - Absolute Quantification by Standard Curve
    - Relative expression
  - Applications of Real-time PCR
    - Absolute quantification
    - Relative expression
    - Genotyping / Allelic Discrimination
- **Sequencing**
  - Basic Sequencing methods
    - Chemical (Maxam-Gilbert) Sequencing
    - Dideoxy (Sanger) Sequencing
  - Next Generation Sequencing

- Sequencing Assays
  - Whole Genome sequencing (WGS)
  - Exome Sequencing
  - RNA-seq
  - CHiP-seq
- **Molecular Cloning**
  - Vectors, restriction enzymes and competent cells
  - Transformation & selection techniques
- **Cell culture**
  - Introduction to cell lines
  - Cell culture components, methodology and applications

PRACTICALS

1. DNA and Protein Sequence retrieval from sequence databases.
2. Nucleic acid extraction by organic and inorganic methods
3. Quantity and Quality check of DNA
4. PCR Primer design and validation
5. DNA electrophoresis
6. Conventional PCR
7. Gradient PCR

RECOMMENDED BOOKS

1 Allison, L.A., 2011. Fundamental Molecular Biology. 2nd Edition. Wiley Sons.
2 Gerald Karp, G., Janet Iwasa, J., Wallace Marshall, W., 2016. Karp's Cell and Molecular Biology, 8th Edition. John Willey and Sons, Inc.
3 Kormann, M.S.D., 2016. Modern Tools for Genetic Engineering. Publisher: InTech Janeza Trdine 951000 Rijeka, Croatia - European Union.
4 Larramendy, M.L., and Soloneski, S., 2016. Nucleic Acids From Basic Aspects to Laboratory Tools Publisher: In Tech, Janeza Trdine 951000 Rijeka, Croatia EUROPEAN UNION
5 Lodish., H., Berk, A., Kaiser, C.A. M. Krieger, M., Bretscher, A., Ploegh, H., Martin, K., 2016. Molecular Cell Biology. 8th Edition. W.H. Freeman.
6 Old R. W. and Primrose, S.B., An Introduction to Genetic Engineering, Blackwell Scientific Publications.
7 Watson, J.D., Gann, A., Levine, M., Losicks, R., 2013. Molecular Biology of the Gene. The Benjumen Cummings Publishing Company, California Wilson, J. and Hunt, T., 2015.
8 Alberts, B., Alexander, J., Lewis, J., Morgan, D., Raff, M., Roberts, K. and Walter. P., Molecular Biology of the Cell. 6th Edition Garland Sciences, Taylor and Francis.

MOLECULAR PATHOLOGY AND DIAGNOSTICS

Credit Hrs 2+1

Objectives

- To understand basic concepts of molecular pathology
- To know how to analyse pathological condition at molecular level

Learning Outcomes

Upon successful completion of the subject, students should:

- Be able to describe the molecular basis of diseases
- Be able to explain how molecular biology may be used in diagnosis of the diseases
- Be able to explain translational aspects of molecular pathology including molecular diagnostics, molecular assessment, and personalized medicine

Course Contents

- **Principals of Molecular Pathology**
- **Genetic and Sporadic Basis of Diseases**
    - Hereditary factors
    - Oncogenes
    - Tumour suppressors
    - Fusion genes
    - Environmental factors
- **Mendalian Mode of Inheritance**
    - Autosomal-Dominant and Autosomal-Recessive
    - Sex-Linked Inheritance
- **Complications of Basic Mendalian Pattern**
- **Deviation from Mendel's Law and Alterations in Gene Expression**
- **Multifactorial Mode of Inheritance**
    - Traditional Approaches to Investigating Multifactorial Traits
- **Identifying Human Disease Genes and Susceptibility Factors**
    - Positional cloning and candidate gene approach
    - Genome wide association studies
    - Genetic mapping of Mendelian characters
    - CRISPR

- **Pedigree Construction**
- **Genetic Mapping of Mendelian Characters**
    - The role of recombination in genetic mapping
        - Recombination fraction
        - Mapping function
    - Two-point mapping and Multipoint mapping
- **Mapping Genes Conferring Susceptibility to Complex Diseases**
    - Family studies of complex diseases
    - Segregation analysis
    - Linkage analysis
    - Association studies and Linkage Disequilibrium
- **Molecular Basis and Diagnosis of Genetic Disorders**
    - Neurological disorders (Deafness, vision)
    - Neuromuscular disorders (Muscular Dystrophy, Macular Leukodystrophy)
    - In born errors of metabolism (Phenylketonuria)
    - Cystic fibrosis and Thalassemia
    - Haemophilia A & B
- **Molecular Basis of Major Cancers**
    - Breast
    - Colorectal
    - Lungs
    - Liver
- **Cancer Diagnostics and Therapies**
- **Molecular Basis and Diagnosis of Cardiovascular Disease**
    - Coronary and cardiovascular heart diseases
- **Molecular basis of infectious diseases**
    - Hepatitis (HCV and HBV)
    - Human immunodeficiency virus (HIV)
    - Human Papilloma virus
    - Dengue
    - Tuberculosis
- **Diagnosis of infectious diseases and therapeutics**

PARTICLES

1. Nucleic Acid extractions from patient samples (Blood and tissue)
2. PCR based diagnosis of the diseases
3. Enzyme-Linked Immunosorbent Assay (ELISA)
4. Microtomy and staining technique (H&E)

RECOMMENDED BOOKS

1. William B. Coleman, 2009. *Molecular Pathology: The Molecular Basis of Human Disease.* 1st Edition. Elsevier, USA
2. Mohammad A Vasef, 2016. *Diagnostic Pathology: Molecular Oncology.* 1st Edition. Elsevier, USA
3. Robert A. Weinberg, 2013. *The Biology of Cancer.* Garland Sciences
4. Lela Buckingham, 2011. *Molecular Diagnostics Fundamentals, Methods and Clinical Applications*. 2nd Edition. F A Davis Company, USA.
5. William B. Coleman & Gregory J. Tsongalis. 2005. *Molecular Diagnostics: For the Clinical Laboratorian.* 2nd Edition. Humana Press
6. George P. Patrinos, Ansorge W., Phillip B. Danielson, 2016. *Molecular Diagnostics*. 3rd Edition. Academic Press, UK
7. E. van Pelt-Verkuil, W.B. van Leeuwen, R. te Witt, 2017. *Molecular Diagnostics*. 3rd Edition. Springer
8. William B. Coleman, Gregory J. Tsongalis. 2016. *Diagnostic Molecular Pathology: A Guide to Applied Molecular Testing*. 1st edition. Academic Press, UK
9. Mousumi Debnath, Godavarthi B.K.S. Prasad, Prakash S. Bisen. 2010. *Molecular Diagnostics: Promises and Possibilities*. Springer

CYTOGENETICS

Credit Hrs 2+1

Objectives

- An understanding of the laboratory methods used to identify and analyses individual cytogenetic alterations
- Understand cytogenetic alterations and relationships to specific clinical expression

Learning Outcomes

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

- Independently culture, harvest, make slides and stain the chromosomes for the analysis
- Identify the normal as well as abnormal chromosomes
- Interpret the results of the chromosomal analysis and to generate the patient's report

Course contents

- **Introduction to Cytogenetics and the objectives of a clinical Cytogenetics services**
- **Structure and function of chromosomes**
    - Chemical composition & Chromosome structure
    - Telomeres, centromeres and kinetochores, nucleolar organizers, chromomeres
    - Banded chromosomes, Lampbrush chromosomes, Polytene chromosomes, B chromosomes.
- **Variations in chromosome structure:**
    - Duplications, deletions, inversions, and translocations, Iso-chromosomes, ring chromosomes, centric fusions and fissions.
- **Changes in chromosome number**
    - Aneuploidy and euploidy
- **Chromosome Breakage and Instability Syndromes**
- **Sex chromosomes, X chromosome inactivation and Sex chromosome abnormalities**
- **International Laboratory system for Cytogenetics**
- **Preparation of Human Tissues for Cytogenetics studies: Molecular Pathology & Cytogenetics Major**
    - Peripheral blood cell culture and harvesting techniques
    - Bone Marrow and solid organs cell culture and harvesting techniques
    - Amniotic Fluid and Chorionic villi sample culturing techniques
- **Chromosome slide making techniques**
- **G-banding and other banding techniques of Chromosomes**

- **ISCN (International System for Human Cytogenetic Nomenclature) of G-banded chromosomes**
- **Database and Computer Assisted Analysis/Image Reproduction**
- **Molecular Cytogenetics**
    - Fluorescence in Situ Hybridization principles and techniques
    - CGH and Microarray
    - Spectral karyotyping

PRACTICALS

- Cell culturing of peripheral blood
- Harvesting of cultured chromosomes
- Slide making and staining of the chromosomes
- Analysis of the chromosomes through Automated karyotyping system for numerical and structural aberrations
- FISH

RECOMMENDED BOOKS

1. Marilyn S. Arsham, Margaret J. Barch, Helen J. Lawce, 2017. The AGT Cytogenetics Laboratory. 4th edition. Wiley-Blackwell
2. Caroline Astbury, 2011. Clinical Cytogenetics, An Issue of Clinics in Laboratory Medicine, Volume
3. 31-4. 1st edition. Saunders 2011
4. Ram, M. (2010). Fundamentals of cytogenetics and genetics. New Delhi: PHI Learning Private Limited.
5. Czepulkowski, B. (2000). Analyzing Chromosomes. London: BIOS Scientific Publishers.
6. Cytogenetic Laboratory Management: Chromosomal, FISH and Microarray-Based Best Practices and Procedures. (n.d.). John Wiley & Sons, Inc.

ENGLISH (COMMUNICATION SKILLS)

Credit Hrs 2+0

Learning Outcomes:

Students will be able to

2. Enhance language skills
3. Develop critical thinking
4. Meet their scholarly communication needs.

Course Contents:

- Definition
- Elements
- Process
- Purpose
- Qualities
- Barriers

Oral Communication:

- Public Speaking
- Persuasion
- Interviews
- Committee Meetings
- Tutorial Discussion

Listening Skills:

- Efficient Listening
- Barrier

Writing Skills:

- Essay
- Correspondence
- Technical Reports
- Progress Report
- Summary

Academic writing:

- Synopsis writing
- Research paper/term paper (emphasis on style, content, language, form, clarity, consistency)

Reading Skills:

- Efficiently Reading
- Barriers
- Skimming
- Scanning & Steady

Presentation skills:

- Personality development (emphasis on content, style and pronunciation)

Visual Communication:

- Chalkboard
- Transparencies,
- Stencils
- Slides

Public Communication:

- Public Relations
- Advertising

Source of Information:

- Questionnaires
- Library
- Observation
- Experiments.

Academic skills:

- Letter/memo writing
- Minutes of meetings
- Use of library and internet

RECOMMENDED BOOKS:

1. Writing. Advanced by Ron White. Oxford Supplementary Skills. Third Impression 1992. ISBN 0 19 435407 3 (particularly suitable for discursive, descriptive, argumentative and report writing).
2. College Writing Skills by John Langan. McGraw-Hill Higher Education. 2004.
3. Patterns of College Writing (4th edition) by Laurie G. Kirszner and Stephen R. Mandell. St. Martin's Press.
4. Reading. Advanced. Brian Tomlinson and Rod Ellis. Oxford Supplementary Skills. Third Impression 1991. ISBN 0 19 453403 0.
5. Reading and Study Skills by John Langan
6. Study Skills by Richard York.

LABORATORY MANAGEMENT

Credit Hrs 3+0

Learning Outcomes:

Students will be able to:

1. Get familiarization with basics of laboratory management including Laboratory Information System, Expert systems, Accreditation, Leadership & Management

Course Contents:

Overview of Health Facility Management

- Introduction to Health Facility Management, Governance and Leadership
- Laboratory Infrastructure

International Standards and Standardization Bodies

- ISO (International Organization of Standardization) - ISO 9000, ISO 9001, ISO 15189 and ISO 17025
- CAP (College of American Pathologists)
- CLSI (Clinical and Laboratory Standards Institute)
- CLIA (Clinical Laboratory Improvement Amendments)
- WHO (World Health Organization)
- Certification and Accreditation

Quality Management System

- Quality Control
- Quality Issues of Pre-Analytic, Analytic, and Post-Analytic Problems
  Quality Assurance in Laboratory Services;
- Quality System and Total Quality Management
- Benchmarking and Performance Monitoring
  Management of Laboratory Records, Documents and Standard Operating Procedures (SOPs)

Laboratory Resource Management

- Management of Laboratory Equipment
- Management of Laboratory Chemical and Reagents
- Laboratory Financing and Budgeting
- Purchasing and Inventory Management

Organization and Personnel Management

- Conflict Management
- Employee Selection
- Compensation, and Workload Adjustments
- Performance Appraisals and Competency Assessment

Managing Laboratory Testing Process

- Specimen Management and Reporting

- Point of Care Testing;
- Principles of Outbreak Management and the Role of Laboratory in Investigation of Disease Outbreaks

Laboratory Management of Information Systems

- Laboratory Information System (LIS)
- The CPT System, Types of CPT Codes and Procedure Coding Guidance

Laboratory Evaluation and Continual Improvement

- Laboratory Audits and Management of Non-conformities
- Regulatory Requirements
- Fundamentals and Process of Laboratory Support Supervision and Mentorship
- Effective Administration of Laboratory Services

Customer service and Management Review

- Customer Service; Management Review
- Development of a Strong Marketing Program

Information Management, Utilization and Application

- Introduction to Basic Data Analysis and Utilization
- Introduction to Operational Research
- Fundamentals of Monitoring and Evaluation

The Future of Pathology and Laboratory Medicine

- Political, Social, Economic, and Regulatory Impacts
- Bioterrorism
- Issues Affecting Research and Academic Laboratories
- Electronic Health Records
- Current Trends in Instrumentation and Technology

RECOMMENDED BOOKS:

1. Lynne S. Garcia (2014). Clinical Laboratory Management, 2nd Edition.
2. Dr. Denise M. Harmening. (2012). Laboratory Management, Principles and Processes, 3rd Edition. D.H. Publishing & Consulting Inc.
3. Jane Hudson (2003). Principles of Clinical Laboratory Management: A Study Guide and Workbook, 1st Edition.
4. Kinkus Candis A. Laboratory Management: Quality in Laboratory Diagnosis, Lab Med (2015) 46 (1).
5. Sergio Petrozzi (2012). Practical Instrumental Analysis: Methods, Quality Assurance and Laboratory Management.
6. Laboratory Quality Management System: Handbook. WHO Library Cataloguing-in Publication Data.
7. Lionel A. Varnadoe (2008). Medical Laboratory Management and Supervision, 2nd Edition.

BIOSAFETY AND BIOETHICS

Credit Hrs 2+0

Learning Outcomes:

The students will able to:

1. Identify safety procedures in experimental medical laboratory sciences
2. Able to address ethical issues emerging with advancements in medical laboratory sciences.

Course Contents:

Biosafety:

- Introduction to Biosafety risks related to genetically modified organisms (GMO) and biohazards
- Detailed concept of risk and hazardous environment, chemicals, biological factors and radiations

Risk assessment & management:

- Preventions
- Surveillance and monitoring

Concepts of Biosafety Environment:

- Terrestrial, Marine, Atmosphere
- Good laboratory practices
- Designing of labs based on Biosafety and Biological Containment parameters
- Biosafety Levels

Details of Biological Containment:

- Plants, Animals, Microbes
- Bioethical issues related to Biosafety
- Biosafety guidelines from a national perspective

Bioethics:

- Introduction to Bioethics definition, concept, uses and abuses of genetic information
- ethical issues related to medical laboratory Sciences
- Role of national bioethics committees
- international rules and regulations for biosafety and bioethics.
- Intellectual property right.
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RECOMMENDED BOOKS:

1. Deepa, G. 2013. IPR, Biosafety and Bioethics. Pearson publishing, NY United States of America.
2. Fleming, D.O., and D.L. Hunt, D.L. 2006. Biological Safety. Principles and Practices, 4th edition, ASM Press, Washington, D.C.
3. US Health Department. 2016. Biosafety in Microbiological and Biomedical Laboratories Edition 5. Books Express Publishing.US
4. Horst, K.N., 2011. Biosafety Cabinet .Dig Press.
5. Torrance, I. Bio-ethics for new Millenium, Saint Andrew Press. 2000.

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