COURSE OF STUDIES

for

Master of Philosophy

in

<Immunology>

UNIVERSITY OF HEALTH SCIENCES, LAHORE PAKISTAN

Program Rationale:

The immunology program aims at developing knowledge and providing basic and clinical research and learning opportunities in the field of immunology. Students of this program will be able to enhance their critical thinking, practical, and analytical skills which will help them become good researchers.

Mission Statement:

The mission of an immunology program is to educate students about the principles and concepts of immunology, enabling them to understand the immune system's complexities and its impact on human health and disease.

Program Educational Objectives:

1. To provide students with a strong foundation that emphasises applying the fundamental and clinical principles of Immunology.
2. To equip the students with laboratory instruments and techniques needed for basic and applied research and develop interdisciplinary research expertise.
3. To develop competencies in assimilating scientific information, writing, research execution, and data presentation on scientific forums.
4. Develop and practice a range of transferable skills during the practicals, including teamwork, software applications, and data analysis.
5. To provide students with skills to enter the workplace well-prepared in the core competencies of the discipline.

Program Learning Outcomes:

1. **Knowledge:** Students will gain a deep understanding of immunological concepts and mechanisms.

2. **Critical thinking:** Students will develop skills of critical thinking to analyze immunological clinical data, evaluate research findings, and apply knowledge in practical scenarios.
3. **Research skills:** Students will learn to design, conduct, and present immunological research data, contributing to the advancement of the field.
4. **Clinical applications:** Students will understand the lab diagnosis and report interpretation for the management of immune-related diseases.
5. **Collaboration:** Students will develop skills to work effectively with interdisciplinary teams, fostering communication and collaboration between researchers and clinicians.
6. **Career readiness:** Students will be prepared for careers in academia and healthcare.
7. **Lifelong learning:** Students will develop a foundation for continued learning, staying current with emerging trends, technologies, and discoveries in immunology.

SCHEME OF STUDIES (2-Year)

MS/MPhil (Immunology)

Semester #	Course code	Course title	Credit hours		
			Theory	Practical	Total
1		Biostatistics and Research Methodology	2	0	2
		Fundamentals of immunology	2	1	8
		Immunologist's toolbox	2	1	
		Laboratory biosafety and risk management	1	1	
		Elective Course	2	0	2
2		Clinical and Diagnostic Immunology	2	1	8
		Vaccinology and Immunotherapy	2	1	
		Mucosal and Regional Immunology	2	0	
		Elective Course	2	0	2
3	Research (thesis)		6		6
4	Professional & Teaching Skills Apprenticeship (PTSA)		0		2
					(Total: 30)

Course Title: Fundamentals of Immunology

Contact Hours: 5	Credit Hours: 2 + 1
Theory = 2	Theory = 2
Practical = 3	Practical = 1
Total = 5	Total = 3

Course Objective:

In this course, students will be introduced to the fundamental concepts of innate and adaptive immunity.

Learning Outcome:

At the end of this course, students will be able to have a comprehensive understanding of:

1. Components and functions of the innate and adaptive immune system.
2. Recognition of the antigen by the innate immune system and mounting of effector immune responses.
3. Characteristics of antigens.
4. Development and maturation of lymphocytes in the bone marrow.
5. Generation of diverse antibody repertoire.
6. Properties and effector functions of antibodies during primary and secondary immune responses.
7. Processing and presentation of antigens by antigen-presenting cells to T cells.
8. Different types of T cell receptors.

9. Effector T cells and their functions.
10. MHC/HLA genes and their diversified products.
11. Immune regulation and orchestration by various cytokines.
12. Mechanisms of tolerance induction.

Course Outline:

Innate immunity

- Components of the non-specific immune system
- Mechanical, chemical, and biochemical barriers
- Biology of natural killer cells, polymorphonuclear phagocytes, macrophages, and other major cellular components in the innate immunity
- Phagocytosis
- Opsonization
- Proprieties of antigens
- Receptors and molecules: Cytokines and receptors, chemokines and receptors, Pathogen recognition
- Complement system and regulation
- Molecular and cellular mechanisms involved in inflammation

Antigens:

- Structure
- Properties
- Types

Specific acquired immunity

The lymphoid system:

- Components**,** anatomy, and physiology
- Lymphatic system

B cell biology:

- B-cell maturation, activation, differentiation, and memory
- The B-cell receptor
- Phases of humoral immune response
- The basic structure of antibodies
- Antibody binding site
- Antibody-mediated effector functions
- Antibody classes and biological functions
- Serological analysis of antibodies: Isotype, Allotype, Idiotype
- Antibody diversity
- Antibody gene and repertoires
- Antibody class switching
- Antibody affinity maturation
- B cell responses
- Primary and secondary immune response

T cell biology:

- Hemopoietic stem cells, growth factors, lymphoid progenitors
- T cell development, activation, and differentiation
- Clonal selection theory
- T-cell antigen receptor
- T-cells subpopulation

Antigen-presenting cells

- Types and properties

MHC/HLA molecules

- Major histocompatibility complex genes
- Antigens recognition: T-dependent and T-independent antigens
- Antigen processing and presentation pathways
- Endogenous Antigen: The cytosolic pathway
- Exogenous Antigens: The endocytic pathway
- Cell-cell communication in the immune system
- Cross presentation
- HLA/ MHC restriction

Cytokines

- Types
- Functions
- Signaling
- Immune regulation

Tolerance:

- Mechanism of central and peripheral tolerance

Practicals

- Agglutination tests (CRP, RF, ASOT, Widal test, Immunochromatographic tests)
- Precipitation test and Nephelometry
- Spectrophotometry

Recommended books

- Virella Gabriel Medical Immunology, 7th Edition
- Janeway's Immunobiology 9th ed
- Essentials of Clinical Immunology by Mansel Haeney, Neil Snowden, Siraj A. Misbah, Helen Chapel, 6th Edition
- Medical Immunology, by Parslow, Tristram G., Stites, Daniel P 10th Edition
- Manual of Molecular and Clinical Laboratory Immunology. Editor(s): Barbara Detrick, John L. Schmitz, Robert G. Hamilton. 2016

- Immunology, A Short Course, Fourth Edition Eli Benjamini, Richard Coico, and Geoffrey Sunshine
- Roitt's Essential Immunology, 13th edition
- Kuby Immunology, 8th edition

Course Title: Immunologist's Toolbox

Contact Hours:	Credit Hours: 2+1
Theory = 2	Theory = 2
Practical = 3	Practical = 1
Total = 5	Total = 3

Course Objective:

In this course, students will be introduced to the principles and applications of various techniques and methods used in the laboratory of immunology

Learning Outcome:

At the end of this course, students will understand the principles and applications of various methods used for the characterization of immune cells and their secretions at the cellular and molecular levels.

Course contents

- Principles of instrumentation
- Agglutination
- Precipitation
- Immunoelectrophoresis
- Complement fixation tests

- Enzyme-linked immunosorbent assay
- Radioimmunoassay
- Immunofluorescence
- Flow cytometry
- Chemiluminescence
- Spectrophotometry
- Polymerase chain reaction
- Microarray
- Electrophoresis
- Luminex assay
- Phage display technology
- Genome editing (CRISPR-Cas9) and gene therapy
- Western blotting
- ELISpot Assay

Practicals

- Demonstration of a flow cytometer
- Demonstration of thermocycler
- Demonstration of fluorescent microscope
- Demonstration of DNA gel documentation system
- Demonstration of ELISA reader

Recommended books

- Virella Gabriel Medical Immunology, 7th Edition
- Janeway's Immunobiology 9th ed
- Essentials of Clinical Immunology by Mansel Haeney, Neil Snowden, Siraj A. Misbah, Helen Chapel, 6th Edition
- Medical Immunology, by Parslow, Tristram G., Stites, Daniel P 10th Edition
- Manual of Molecular and Clinical Laboratory Immunology. Editor(s): Barbara Detrick, John L. Schmitz, Robert G. Hamilton. 2016
- Immunology, A Short Course, Fourth Edition Eli Benjamini, Richard Coico, and Geoffrey Sunshine
- Roitt's Essential Immunology, 13th edition
- Kuby Immunology, 8th edition

Course Title: **Laboratory Biosafety and Risk Management**

• Contact Hours:	Credit Hours: 1+1
• Theory = 1	Theory = 1
• Practical = 3	Practical = 1
• Total = 4	Total = 2

- **Course Objective:**

In this course, students will be introduced to the fundamental concepts of laboratory biosafety and risk management.

- **Learning Outcome:**

At the end of this course, students will understand biosafety principles, biosafety levels, risk assessment and management, laboratory safety practices, biological agent classification, biosecurity measures, laboratory facility design and maintenance, and ethical and legal considerations.

Course Contents

Introduction to biosafety and its importance in biological sciences

- Biological Risk Assessment, steps in risk assessment, information requirements for risk assessment, the key steps in risk management, and socio-economic considerations, risk communication, when to communicate about risk, applying risk communication principles in risk analysis, facilitating public engagement in the risk analysis process
- Biosafety Levels
    - BSL1 and 2: Code of practice, Laboratory design and facilities, Laboratory equipment, Health and medical surveillance, Training, Waste management, Chemical, fire, electrical, radiation, and equipment safety
    - BSL3 Laboratories: Code of practice, Laboratory design and facilities, Laboratory equipment, Health and medical surveillance
    - BSL4 Laboratories: Code of practice, Laboratory design, and facilities
- Biological safety cabinets: Class I -III biological safety cabinets, biological safety cabinet air connections, Selection of a biological safety cabinet, Using biological safety cabinets in the laboratory, Good microbiological techniques

Practicals

- Demonstration of hand washing and hand rubbing technique.
- Demonstration of cleaning and disinfection of working premises.
- Demonstration of cleaning and disinfection of biosafety cabinets.
- Demonstration of how to handle spills and aseptic handling.
- Management of needle prick injury
- Emergency response exercise
- Donning and doffing of PPEs

Recommended books

- Biosafety Resource Book: risk analysis, Module C, Food and Agriculture organization of the united Nations Rome, 2011
- Laboratory biosafety manual, Third edition, World Health Organization, Geneva, 2004

- Biosafety in Microbiological and Biomedical Laboratories, 5th Edition, U.S. Department of Health and Human, CDC

Course Title: **Clinical and diagnostic immunology**

• Contact Hours:	Credit Hours: 3+1
• Theory = 2	Theory = 3
• Practical = 3	Practical = 1
• Total = 5	Total = 4

Course Objective:

In this course, students will be introduced to the fundamental concepts of hypersensitivity, tolerance, autoimmunity, immunodeficiency, infection and immunity, transplantation, and immunity against tumours. Besides they will be introduced to methods involved in the clinical immunology labs.

Learning Outcome:

At the end of this course, students will

1. Understand the principles of immunological testing and interpretation

2. Identify and diagnose immunological disorders, such as autoimmune diseases and immunodeficiencies

3. Gain knowledge of immunological mechanisms to understand disease pathogenesis

4. Interpret laboratory results, including serology, molecular diagnostics, and flow cytometry

5. Understand the clinical applications of immunological tests, including allergy testing

6. Develop skills in critical thinking and problem-solving in diagnostic immunology

7. Integrate knowledge of immunology and laboratory medicine to diagnose and manage diseases

8. Understand the limitations and pitfalls of immunological testing

9. Apply evidence-based medicine to diagnose and manage immunological disorders

10. Communicate effectively with patients, families, and healthcare professionals regarding immunological disorders and test results.

Course Contents

Hypersensitivity reactions:

Type I hypersensitivity, Type II hypersensitivity, Type III hypersensitivity reactions, Type IV hypersensitivity, Laboratory testing, considerations and interpretation of results

Autoimmune disorders:

Spectrum and classification of autoimmune diseases and clinical burden**,** Immunological features of autoimmune disease**,** Etiology of autoimmune diseases (Genetic factors, Environmental factors, Loss of tolerance), Laboratory testing, considerations and interpretation of results

Immunodeficiency:

Congenital immunodeficiencies**:** Defects in innate immunity, complement disorders**,** Severe combined immunodeficiencies**,** Antibody Deficiencies: Defects in B cell development activation, Defects in T lymphocyte activation and function**,** Therapeutic approaches for congenital immunodeficiency

Acquired immunodeficiencies: Molecular and biological features of HIV, Pathogenesis of HIV Infection and AIDS, Clinical features of HIV disease, Immune responses to HIV, Mechanisms of immune evasion by HIV, A role for host genes, Diagnosis of HIV, Treatment and prevention of AIDS, Laboratory testing, considerations and interpretation of results

Infection and immunity:

Immune responses to viruses: Innate and adaptive immunity, Immune evasion strategies

Immune response to bacteria: Innate and adaptive immunity to extracellular bacteria, Immune evasion strategies, Innate and adaptive immunity to intracellular bacteria, Immune evasion by intracellular bacteria

Immune response to fungi: Innate and adaptive immunity to fungi, Immune evasion strategies

Immune response to parasites: Innate and adaptive immunity to parasites, Immune evasion by parasites

Laboratory testing, considerations and interpretation of results

Transplantation:

Types, Transplantation antigens, Immune responses to transplants, Adaptive immune responses to allografts, The nature of alloantigen, Recognition of alloantigens by T cells, Activation and effector functions of alloreactive T lymphocytes, Activation of alloreactive B cells and production and functions of alloantibodies, Patterns and mechanisms of graft rejection, Accelerated rejection, Hyperacute rejection, Acute rejection, Chronic rejection and graft vasculopathy, Methods to reduce the immunogenicity of allografts, Immunosuppression to prevent or to treat allograft rejection, Methods to induce donor-specific tolerance, Compatibility testing, Hematopoietic stem cell transplantation, Graft-versus-Host Disease

Tumour immunology:

Biology of cancers, Immune recognition, Tumour antigens- products of mutated genes abnormally expressed but unmutated cellular proteins, antigens of oncogenic viruses, oncofetal antigens, altered glycolipid, and glycoprotein antigens, tissue-specific differentiation antigens, Etiology and pathogenesis of tumours, Immune responses to tumours, Evasion of immune responses by tumours, Immunotherapy for tumours

(Checkpoint blockade, CAR T and novel therapies), Laboratory testing, considerations and interpretation of results

Diagnosis of immunological disorders:

Specimen collection, handling, transport, biohazards/biosafety measures, and quality control measures in an immunology laboratory, Handling and use of animal models, Evaluation of the complement function, Evaluation of cellular immunity, Evaluation of humoral immunity, Allergy diagnosis

Clinical training/Practicals

- Radial Immunodiffusion for microbial antigens
- Ouchterlony double diffusion to identify fungal antigen (*Candida*)
- Anti Streptolysin O Titer
- Detection of HBsAg and Anti-HCV by ELISA
- HLA Typing
- Mixed lymphocyte reactions for transplantation
- Luminex assay demonstration
- Immunophenotyping by Flow Cytometry for B cells, T cells, Natural killer cells
- Serum protein electrophoresis
- Immunophenotyping of leukemias
- Skin prick test for allergens
- Serum total IgE test
- Radio-immunosorbent test (RIST)
- Radio-allergosorbent test (RAST)
- Direct antiglobulin testing (DAT) for autoimmune hemolytic anemia
- Fluorescent staining for deposition of immune complexes
- The patch test for contact dermatitis
- Antinuclear antibodies (ANA) in SLE patients
- Double-stranded DNA in SLE Patients
- Slide agglutination test for the detection of rheumatoid factor
- Antithyroglobulin antibody by ELISA

- Antithyroid peroxidase antibody by ELISA
- Anti-TSH receptors antibody by ELISA
- Anti-islet cells antibody by ELISA
- Rocket Immunoelectrophoresis to quantitate immunoglobulins
- Immunoelectrophoresis for the detection of myelomas, Waldenström's macroglobulinemia, malignant lymphomas
- Immunofixation electrophoresis for Waldenström's macroglobulinemia and multiple myeloma
- Direct immunofluorescence assay for Pemphigus vulgaris and Bullous pemphigoid
- Indirect immunofluorescence assays for autoimmune bullous diseases
- Serum protein electrophoresis
- Western blot for identification of HIV antigens

Recommended books

- Virella Gabriel Medical Immunology, 7th Edition
- Janeway's Immunobiology 9th ed
- Essentials of Clinical Immunology by Mansel Haeney, Neil Snowden, Siraj A. Misbah, Helen Chapel, 6th Edition
- Medical Immunology, by Parslow, Tristram G., Stites, Daniel P 10th Edition
- Manual of Molecular and Clinical Laboratory Immunology. Editor(s): Barbara Detrick, John L. Schmitz, Robert G. Hamilton. 2016
- Immunology, A Short Course, Fourth Edition Eli Benjamini, Richard Coico, and Geoffrey Sunshine
- Roitt's Essential Immunology, 13th edition
- Kuby Immunology, 8th edition

Course Title: Vaccinology and Immunotherapy

- Contact Hours: Credit Hours: 2+1
- Theory = 2 Theory = 2
- Practical = 3 Practical = 1
- Total = 5 Total = 3

Course Objective:

The students will be introduced to the concepts of vaccinology and immunotherapy

Learning Outcome:

At the end of this course, students will be able to

1. Understand the principles of vaccine development and immunotherapy approaches.

2. Know the different types of vaccines and their characteristics

3. Understand the immune response to vaccines and how they confer protection

4. Learn about vaccine-preventable diseases and their epidemiology

5. Understand the role of vaccines in public health and disease prevention

6. Develop critical thinking skills to evaluate vaccine safety and efficacy

7. Apply knowledge to address vaccine hesitancy and misinformation

8. Understand the ethical and legal considerations in vaccine development

9. Develop skills to design and implement effective vaccine programs

10. Understand clinical trials for vaccine development

11. Know the different types of immunotherapies (e.g., monoclonal antibodies, checkpoint inhibitors, cancer vaccines)

12. Understand the immune response and how immunotherapy modulates it

13. Understand the functional assays of vaccines

Vaccinology

- Active immunotherapy
- Passive immunotherapy
- Herd immunity
- Adjuvants and immune activation
- New approaches to vaccine development
- Types of vaccines
- The durability of immune responses
- Vaccine safety
- Vaccine hesitancy
- Role of vaccines in public health and disease prevention
- Ethical and legal considerations in vaccine development
- Experimental approaches for vaccine development
- Pre-clinical evaluation
- Human clinical trials (stages)

Immunotherapeutics

- Glucocorticoids: Immunosuppressive mechanism, Anti-inflammatory effects
- Cytostatics: Alkylating agents, Antimetabolites
- Antibodies: Polyclonal antibodies, Monoclonal antibodies

- Drugs acting on immunophilins: Ciclosporin, Tacrolimus, Sirolimus, Everolimus
- Other Immunomodulatory drugs: Interferons, Opioids
- TNF binding proteins: Mycophenolate, Small biological agents
- Cancer immunotherapy
- Immune modulation
- Biomarkers in immunotherapy

Assays for testing of immunotherapeutic agents

Setting up a cell culture laboratory, The physical environment, Media, Standard cell culture techniques, Cells visualization techniques, Sterilization, Contamination management, Serum-free culture, Primary cultures, Special growth conditions, Cell culture, cell types, and morphology of cells in culture, Primary and secondary culture, cell strains, Establishment of cell lines, Functional assays, *In vitro* and *In vivo* assays for testing

Practicals

- Starting a primary culture (tissue digestion, cell count, and cell culture)
- Maintenance of a cell line
- Cryopreservation of cell line
- Culturing of different cell lines and lymphocytes in the lab

Recommended books

- Virella Gabriel Medical Immunology, 7th Edition
- Janeway's Immunobiology 9th ed
- Essentials of Clinical Immunology by Mansel Haeney, Neil Snowden, Siraj A. Misbah, Helen Chapel, 6th Edition
- Medical Immunology, by Parslow, Tristram G., Stites, Daniel P 10th Edition
- Manual of Molecular and Clinical Laboratory Immunology. Editor(s): Barbara Detrick, John L. Schmitz, Robert G. Hamilton. 2016

- Immunology, A Short Course, Fourth Edition Eli Benjamini, Richard Coico, and Geoffrey Sunshine
- Roitt's Essential Immunology, 13th edition
- Kuby Immunology, 8th edition

Course Title: **Mucosal and regional immunology**

Contact Hours:	Credit Hours: 2+ 0
Theory = 1	Theory = 2
Practical = 0	Practical = 0
Total = 1	Total = 2

Course Objective:

The students will be introduced to the concepts of mucosal and regional immunology

Learning Outcome:

At the end of this course, students will be able to

1. Understand the unique features of mucosal immune systems (e.g., gut, lung, genital tract)

2. Know the mechanisms of mucosal immune responses to pathogens, allergens, and commensals

3. Learn about the role of mucosal immunity in health and disease (e.g., pregnancy, infection, inflammation, cancer)

4. Understand the interactions between the mucosal immune system and the microbiome

5. Develop critical thinking skills to evaluate the efficacy of mucosal vaccines and therapies

Course Contents

- The mucosal immune system

- Protective mucosal immune responses
- Immune response to pathogens, allergens, and commensals
- Repertoire of lymphocytes
- Influences on mucosal immunity
- Mucosal tolerance and disease
- Role and regulation of IgA
- Immunology of pregnancy
- Immunologically privileged sites
- Microbiome, inflammation, cancer and immunity
- Mucosal vaccines

Recommended Books:

- Virella Gabriel Medical Immunology, 7th Edition
- Janeway's Immunobiology 9th ed
- Essentials of Clinical Immunology by Mansel Haeney, Neil Snowden, Siraj A. Misbah, Helen Chapel, 6th Edition
- Medical Immunology, by Parslow, Tristram G., Stites, Daniel P 10th Edition
- Manual of Molecular and Clinical Laboratory Immunology. Editor(s): Barbara Detrick, John L. Schmitz, Robert G. Hamilton. 2016
- Immunology, A Short Course, Fourth Edition Eli Benjamini, Richard Coico, and Geoffrey Sunshine
- Roitt's Essential Immunology, 13th edition
- Kuby Immunology, 8th edition