Semester: 4	
Course: Major 2	
PaperTitle: Immunology	
Paper Code: C2BT230421T	**Credits: 4**
Hours/week: 4	
Category: Core/MDC/SEC/VAC: Core	
Theory / Practical / Composite: Theory	
No of Modules: 2 (A + B)	

Course Overview:

- This course introduces our students to vertebrate's immune system.
- They are provided with a comprehensive understanding of the two types of immune response against a foreign substance - innate and adaptive, and how they are connected through the induced innate immunity, also called inflammatory response.
- Emphasis is given on thorough understanding of the time-line of the different immune responses.
- Knowledge of organs, tissues, cells and molecules involved in the various stages of immune response is imparted to the students.
- Specificity of immune reactions at the level of innate immunity is ensured by germ-line encoded receptors, and is discussed elaborately with examples of pathogen associated molecular patterns (PAMPs) and their cognate receptors, pattern recognition receptors (PRRs).
- Stress is given on the two unique features of adaptive immune response – diversity and memory.
- Antigen recognising receptors of the two lymphocytes B-cell (BCRs) and T-cell (TCRs), the key players of adaptive immune response, are made by gene segment rearrangement and are dealt with at molecular level.
- This module will set the foundation for a future module (Advanced Immunology) that will deal with applications of the immune system in research, medicine, and pharmaceutical industries.

Course Outcome:

Module A

1. Remember Students will be able to recall the historical development of Immunology as a subject and its landmark discoveries, fundamental immunological concepts including innate and adaptive immunity, humoral and cell-mediated immune responses, and herd immunity, major types of human pathogens and mechanisms of pathogenesis, components of the immune system including cells, organs, and molecular mediators, and the principal components of the three pathways of complement activation (classical, lectin and alternative).

2. Understand Students will develop an understanding of the recognition of foreign antigens by the immune system including Clonal Selection Theory, pattern recognition through pathogen-associated molecular pattern (PAMP) - pattern recognition receptor (PRR) interactions and their role in initiating innate immune responses, the basis of inappropriate / dysfunctional immune responses, the cellular and molecular organization of the immune system including

hematopoiesis process, functional roles of myeloid and lymphoid cell lineages including antigen-presenting cells (APCs) and lymphocyte subsets, the organization and microenvironments of primary, secondary, and tertiary lymphoid organs, the mechanisms of innate immunity including anatomical (physical, chemical, and cellular) barriers to infections, inflammation, and the biological significance of the complement proteins, including that of the membrane attack complex (MAC).
3. Apply Students will apply immunological principles to explain host defense mechanisms against infectious agents, and demonstrate application of innate immune responses such as phagocytosis, inflammatory signaling, and antimicrobial activity.
4. Analyze Students will analyze the regulatory roles of complement proteins, and consequences of complement deficiencies.
5. Evaluate Students will critically evaluate ubiquity of innate immune strategies across organisms, including plant innate immunity.
6. Create Students will be able to integrate molecular, cellular, and systemic immunological concepts to construct comprehensive immune response models, and develop immunological knowledge relevant to vaccination, immunopathology, and therapeutic intervention.
Module B
1. Remember Students will remember the key components of the adaptive immune response that include lymphocytes (B and T cells) and antigen presenting cells (Dendritic cells, macrophages and B cells), along with their signature molecules.
2. Understand Students will understand the structure-function relationship of immunoglobulins and how it led to the discovery of a unique phenomenon 'gene segment rearrangement', the source of diversity, specificity and memory attributes of adaptive immune response.
3. Apply Students will apply the concept of gene segment rearrangement to appreciate how a vertebrate's immune system is ready to combat nearly any pathogen entering it, at any point of time.
4. Analyze Students will analyze the pros and cons of generation of B and T lymphocytes, more specifically the B cell receptors (BCRs) and T cell receptors (TCRs), by gene segment rearrangement. Pros – diversity, specificity and memory while cons – generation of self-reactive T and B lymphocytes that may lead to improper immune responses as in autoimmune disorder.
5. Evaluate Students will evaluate the selection procedures that can eliminate the 'con effect' of gene segment rearrangement. Majority of the self-reactive T- and B-cells are eliminated in selection procedures in thymus and bone marrow respectively (central tolerance). Regulatory T cells (T_{reg}) are the main mediator of peripheral tolerance. Students will also evaluate the process of self-MHC-restriction in the presentation of antigenic peptides to T cells, as MHC molecules are germline encoded with apparent limited diversity, relative to a diverse range of T cells.
6. Create Students will create a comprehensive chart showing inter-connectivity between innate and adaptive immunity, and also intra-connectivity between the different aspects of adaptive immune response. Intricate regulatory mechanisms to keep a check on the extent of immune response need special mention.

Prerequisites: **Basic knowledge about Human Physiology, Cell Biology, Microbiology**				
SYLLABUS				
UNIT/Module	**CONTENT**	**HOURS or NUMBER OF CLASSES**	**CO Mapping**	**COGNITIVE LEVEL**
MODULE A [18 marks]	**UNIT I: Overview of the Immune System:** A historical perspective of Immunology; concept of herd immunity; humoral & cellular immune responses; recognition of foreign substances by the immune system (including Clonal Selection Theory); pathogens and pathogenesis; PAMPs and PRRs; innate and adaptive immune responses (including memory responses); inappropriate or dysfunctional immune responses.	1 class/ week	CO1 – CO6	K1 – K6
	UNIT II: Cells, Organs, and Micro-environments of the Immune System: Cells of the Immune System: hematopoietic stem cells and hematopoiesis; cells of the myeloid lineage (granulocytes: neutrophils, basophils, mast cells and eosinophils; professional antigen-presenting cells: monocytes, macrophages, and dendritic cells); cells of the lymphoid lineage (lymphocytes: B-lymphocytes, T-lymphocytes, NK cells and NKT cells); **Organs of**			

	the Immune System: primary lymphoid organs (bone marrow and thymus); secondary lymphoid organs (lymph nodes, spleen and mucosa-associated lymphoid tissue, including respective microenvironments); tertiary lymphoid tissues.			
	UNIT III: Innate Immunity: Anatomical barriers to infection (physical: skin and other epithelial barriers; chemical: acidic pH and antimicrobial proteins & peptides; cellular: phagocytes, phagocytosis and Toll-like receptors); inflammatory responses; ubiquity of innate immunity (including plant innate immune responses).			
	UNIT IV: The Complement System: Components of the complement system; major pathways of complement activation (Classical, Lectin and Alternative) and membrane attack complex; diverse functions of complements; regulation of complement activity; complement deficiencies.			

Module B [52 marks]	**UNIT V: The Organization and Expression of Lymphocyte Receptor Genes:** Immunoglobulin gene structure; Multigene organization of Ig genes; Mechanism of V(D)J recombination; B-Cell Receptor expression; T-Cell Receptor genes and expression.	3 classes/ week	CO1 – CO6	K1 – K6
	UNIT VI: The Major Histocompatibility Complex and Antigen Presentation: Structure and function of MHC Molecules; General organization and inheritance of MHC; Role of MHC and expression patterns; Endogenous pathway of antigen processing and presentation; Exogenous pathway of antigen processing and presentation; Cross-presentation of exogenous antigens; Presentation of nonpeptide antigens.			
	UNIT VII: T-Cell Development: Early thymocyte development; Positive and negative selection; Lineage commitment; Exit from thymus and final maturation; Other mechanisms that maintain self-tolerance; Apoptosis.			
	UNIT VIII: B-Cell Development: Site of hematopoiesis; B-Cell development in the bone marrow; Development of B-1 and marginal-zone B			

	Cells; Comparison of B- and T-Cell development.			
	UNIT IX: T-Cell Activation, Differentiation, and Memory: T-Cell activation and the two signal hypothesis; T-Cell differentiation; T-Cell memory.			
	UNIT X: B-Cell Activation, Differentiation, and Memory Generation: T-dependent B-Cell responses; T-independent B Cell responses; Negative regulation of B Cells.			

Text Books

Theory text/references

1. Owen JA, Punt J, Stranford SA. (2013). Kuby Immunology. 7th edition. W.H. Freeman and Company, New York.
2. Janeway CA, Travers P Jr, Walport M and Shlomchik MJ. (2001). Immunobiology. 5th edition. Garland Science, New York.
3. Delves P, Martin S, Burton D and Roitt IM. (2006). Roitt's Essential Immunology. 11th edition Wiley-Blackwell Scientific Publication, Oxford.

Evaluation: Theory (100)

CIA- 20; Assignment – 05; Attendance – 05; Semester Exam- 70

Paper Structure for Theory Semester Exam Module:

Module A: (18 marks)

•1 Compulsory Question – objective-type (any 8 out of 10 questions; each of 1 mark): 1 × 8 marks = 8 marks

•Any 2 out of 3 questions; each of 5 marks, with subparts (no sub-part will be more than 3 marks, and less than 1 mark): 2 × 5 marks = 10 marks

Module B: (52 marks)

•1 Compulsory Question – 10 marks

•Any 3 out of 4 questions; each of 14 marks, with subparts (no sub-part will be more than 5 marks, and less than 1 mark): 3 × 14 marks = 42 marks

COURSE OUTCOMES (COS) AND COGNITIVE LEVEL MAPPING

COs	CO Description	Cognitive levels
	Module A	
CO1	**Remember** Students will be able to recall the historical development of Immunology as a subject and its landmark discoveries, fundamental immunological concepts including innate and adaptive immunity, humoral and cell-mediated immune responses, and herd immunity, major types of human pathogens and mechanisms of pathogenesis, components of the immune system including cells, organs, and molecular mediators, and the principal components of the three pathways of complement activation (classical, lectin and alternative).	K1
CO2	**Understand** Students will develop an understanding of the recognition of foreign antigens by the immune system including Clonal Selection Theory, pattern recognition through pathogen-associated molecular pattern (PAMP) - pattern recognition receptor (PRR) interactions and their role in initiating innate immune responses, the basis of inappropriate / dysfunctional immune responses, the cellular and molecular organization of the immune system including hematopoiesis process, functional roles of myeloid and lymphoid cell lineages including antigen-presenting cells (APCs) and lymphocyte subsets, the organization and microenvironments of primary, secondary, and tertiary lymphoid organs, the mechanisms of innate immunity including anatomical (physical, chemical, and cellular) barriers to infections, inflammation, and the biological significance of the complement proteins, including that of the membrane attack complex (MAC).	K2
CO3	**Apply** Students will apply immunological principles to explain host defense mechanisms against infectious agents, and demonstrate application of innate immune responses such as phagocytosis, inflammatory signaling, and antimicrobial activity.	K3
CO4	**Analyze** Students will analyze the regulatory roles of complement proteins, and consequences of complement deficiencies.	K4
CO5	**Evaluate** Students will critically evaluate ubiquity of innate immune strategies across organisms, including plant innate immunity.	K5

CO6	**Create** Students will be able to integrate molecular, cellular, and systemic immunological concepts to construct comprehensive immune response models, and develop immunological knowledge relevant to vaccination, immunopathology, and therapeutic intervention.	K6
	Module B	
CO1	**Remember** Students will remember the key components of the adaptive immune response that include lymphocytes (B and T cells) and antigen presenting cells (Dendritic cells, macrophages and B cells), along with their signature molecules.	K1
CO2	**Understand** Students will understand the structure-function relationship of immunoglobulins and how it led to the discovery of a unique phenomenon 'gene segment rearrangement', the source of diversity, specificity and memory attributes of adaptive immune response.	K2
CO3	**Apply** Students will apply the concept of gene segment rearrangement to appreciate how a vertebrate's immune system is ready to combat nearly any pathogen entering it, at any point of time.	K3
CO4	**Analyze** Students will analyze the pros and cons of generation of B and T lymphocytes, more specifically the B cell receptors (BCRs) and T cell receptors (TCRs), by gene segment rearrangement. Pros – diversity, specificity and memory while cons – generation of self-reactive T and B lymphocytes that may lead to improper immune responses as in autoimmune disorder.	K4
CO5	**Evaluate** Students will evaluate the selection procedures that can eliminate the 'con effect' of gene segment rearrangement. Majority of the self-reactive T- and B-cells are eliminated in selection procedures in thymus and bone marrow respectively (central tolerance). Regulatory T cells (T_{reg}) are the main mediator of peripheral tolerance. Students will also evaluate the process of self-MHC-restriction in the presentation of antigenic peptides to T cells, as MHC molecules are germline encoded with apparent limited diversity, relative to a diverse range of T cells.	K5
CO6	**Create** Students will create a comprehensive chart showing inter-connectivity between innate and adaptive immunity, and also intra-connectivity between the different aspects of adaptive immune response. Intricate regulatory mechanisms to keep a check on the extent of immune response need special mention.	K6