QI. What do you understand by the following terms as they have been discussed in class? (20 PTS)

i. **Immune System –** Immunity refers to protection from disease and other pathogens. Immune system consists of the cells and molecules responsible for immunity and their efforts in regards to any etiological agent is called immune responses.

ii. **Immunology –** This is a branch of life science which deals with the cellular and molecular events occurring in the body after an encounter with micro-organisms and other foreign substances.

iii. **Lymphatic system –** This is a part of the circulatory system and a vital part of the immune system comprising a network of lymphatic vessels that carry a clear fluid called lymph directionally towards the heart. Unlike the cardiovascular system, the lymph system is not a closed system

iv. **Lymph nodes –** A lymph node is an organized collection of lymphoid tissue, through which the lymph passes on its way back to the blood. These lymph nodes are located at intervals along the lymphatic system.

v. **Thymus –** The thymus is a primary lymphoid organ and the site of maturation for T cells, the lymphocytes of the adaptive immune system. The thymus increases in size from birth in response to postnatal antigen stimulation then to puberty and regresses thereafter. The loss or lack of the thymus results in severe immunodeficiency and subsequent high susceptibility to infection.

vi. **Spleen –** This is the organ that synthesizes antibodies in its white pulp and removes antibody-coated bacteria and antibody-coated blood-cells by way of blood and lymph node circulation.

vii. **Thymus –** The thymus is a gland located in the anterior mediastinum just above the heart, which reaches its greatest size just prior to birth then atrophies with age

viii. **Immunogen -**
An immunogen is an antigen or any substance that may be specifically bound by components of the immune system (antibody, lymphocytes). The term antigen arises from its ability to induce generation of antibodies (antigen = antibody generation). Despite the fact that all antigens are recognized by specific lymphocytes or by antibodies, not every antigen can evoke an immune response. Those antigens that are capable of inducing an immune response are said to be immunogenic and are called immunogens. An immunogen is any antigen that is capable of inducing humoral and/or cell-mediated immune response rather than immunological tolerance. This ability is called immunogenicity. Sometimes the term immunogen is used interchangeably with the term antigen. But only an immunogen can evoke an immune response.

ix. **Antigen -** An antigen is a protein expressed by a bacteria or virus that is recognized by the immune system as foreign which can stimulate the production of antibodies and combine specifically with them. Usually an antigen is a molecule, perhaps on the cell surface of a bacterium or virus.

x. **Hapten -** Haptens are small molecules that elicit an immune response only when attached to a large carrier such as a protein; the carrier may be one that also does not elicit an immune response by itself. (In general, only large molecules, infectious agents, or insoluble foreign matter can elicit an immune response in the body.) Once the body has generated antibodies to a hapten-carrier adduct, the small-molecule hapten may also be able to bind to the antibody, but it will usually not initiate an immune response; usually only the hapten-carrier adduct can do this. Sometimes the small molecule hapten can even block immune response to the hapten-carrier adduct by preventing the adduct from binding to the antibody, a process called hapten inhibition.

Q2. State any three functions of the spleen (5PTS)

i. To produce immune response against blood- borne antigens
ii. To remove particulate matter and aged blood cells, mainly erythrocytes
iii. To produce blood cells during foetal life
iv. Promote tissue healing (of internal organs such as the heart)
v. Storage of red blood cells and lymphocytes. (it can actually store enough blood cells to help in an emergency)

Q3. State any three functions of the lymphatic system (5 PTS)

i. It is responsible for the removal of interstitial fluid from tissues
ii. It absorbs and transports fatty acids and fats as chyle from the digestive system
iii. It transports white blood cells to and from the lymph nodes into the bones
iv. The lymph transports antigen-presenting cells (APCs) such as dendritic cells, to the lymph nodes where an immune response is stimulated.

Q4. A vaccine is a substance that stimulates a primary response against an antigen without causing symptoms of the diseases. Discuss the four types of traditional vaccines. (10 pts)

i. Inactivated vaccines are composed of micro-organisms that have been killed with chemicals and/or heat and are no longer infectious. Examples are vaccines against flu, cholera, plague, and hepatitis A. Most vaccines of this type are likely to require booster shots.
ii. Live, attenuated vaccines are composed of micro-organisms that have been cultivated under conditions which disable their ability to induce disease. These responses are more durable and do not generally require booster shots. Examples include yellow fever, measles, rubella, and mumps.
iii. Toxoids are inactivated toxic compounds from micro-organisms in cases where these (rather than the micro-organism itself) cause illness, used prior to an encounter with the toxin of the micro-organism. Examples of toxoid-based vaccines include tetanus and diphtheria.

iv. Subunit vaccines are composed of small fragments of disease-causing organisms. A characteristic example is the subunit vaccine against Hepatitis B virus.

Q5. Explain the following listed factors that influence immunogenicity.

a) Contribution of the immunogen (10 PTS)

- **i. Foreignness -** The immune system normally discriminates between self and non-self, such that only foreign molecules are immunogenic.
- **ii. Size -** There is not absolute size above which a substance will be immunogenic. However, in general, the larger the molecule the more immunogenic it is likely to be.
- **iii. Chemical composition -** In general, the more complex the substance is chemically the more immunogenic it will be. The antigenic determinants are created by the primary sequence of residues in the polymer and/or by the secondary, tertiary or quaternary structure of the molecule.
- **iv. Physical form -** In general particulate antigens are more immunogenic than soluble ones and denatured antigens more immunogenic than the native form.
- **v. Degradability -** Antigens that are easily phagocytosed are generally more immunogenic. This is because for most antigens, the development of an immune response requires that the antigen be phagocytosed, processed and presented to helper T cells by an antigen presenting cell (APC).

b) Contribution of the biological system (10 PTS)

- **i. Genetic factors -** Some substances are immunogenic in one species but not in another. Similarly, some substances are immunogenic in one individual but not in others (i.e., responders and non-responders). The species or individuals may lack or have altered genes that code for the receptors for antigen on B cells and T cells or they may not have the appropriate genes needed for the APC to present antigen to the helper T cells.
- **ii. Age -** Age can also influence immunogenicity. Usually, the very young and the very old have a diminished ability to mount and immune response in response to an immunogen.

c) Method of administration (10 PTS)

- **i. Dose -** The dose of administration of an immunogen can influence its immunogenicity. There is a dose of antigen above or below which the immune response will not be optimal.
- **ii. Route -** Generally the subcutaneous route is better than the intravenous or intragastric routes. The route of antigen administration can also alter the nature of the response.
- **iii. Adjuvants -** Substances that can enhance the immune response to an immunogen are called adjuvants. The use of adjuvants, however, is often hampered by undesirable side effects such as fever and inflammation.

Q6. State and explain four chemical natural composition of immunogens (10 PTS)

i. Proteins - The vast majority of immunogens are proteins. These may be pure proteins or they may be glycoproteins or lipoproteins. In general, proteins are usually very good immunogens.
ii. Polysaccharides - Pure polysaccharides and lipopolysaccharides are good immunogens.
iii. Nucleic Acids - Nucleic acids are usually poorly immunogenic. However, they may become immunogenic when single stranded or when complexed with proteins.
iv. Lipids - In general lipids are non-immunogenic, although they may be haptens which are good immunogens.

Q7. Define Immunoglobin. State and explain two general function of immunoglobins. (10 PTS)

Immunoglobulins are glycoprotein molecules that are produced by plasma cells in response to an immunogen and which function as antibodies. The immunoglobulins derive their name from the finding that they migrate with globular proteins when antibody-containing serum is placed in an electrical field.

GENERAL FUNCTIONS OF IMMUNOGLOBULINS.

i. Antigen binding. - Immunoglobulins bind specifically to one or a few closely related antigens. Each immunoglobulin actually binds to a specific antigenic determinant. Antigen binding by antibodies is the primary function of antibodies and can result in protection of the host. The valency of antibody refers to the number of antigenic determinants that an individual antibody molecule can bind. The valency of all antibodies is at least two and, in some instances, more.

ii. Effector Functions. - Frequently the binding of an antibody to an antigen has no direct biological effect. Rather, the significant biological effects are a consequence of secondary "effector functions" of antibodies. The immunoglobulins mediate a variety of these effector functions. Usually, the ability to carry out a particular effector function requires that the antibody bind to its antigen. Not every immunoglobulin will mediate all effector functions. Such effector functions include:

i. **Fixation of complement** - This results in lysis of cells and release of biologically active molecules.
ii. **Binding to various cell types** - Phagocytic cells, lymphocytes, platelets, mast cells, and basophils have receptors that bind immunoglobulins. This binding can activate the cells to perform some function. Some immunoglobulins also bind to receptors on placental trophoblasts, which results in transfer of the immunoglobulin

across the placenta. As a result, the transferred maternal antibodies provide immunity to the foetus and new-born.

Q8.

a. What are Cytokines? (5 PTS)

Cytokines are small secreted proteins which mediate and regulate immunity, inflammation, and haematopoiesis. They must be produced actively in response to an immune stimulus. They generally (although not always) act over short distances and short time spans and at very low concentration. They act by binding to specific membrane receptors which then signal the cell through second messengers, often tyrosine kinase, to alter its behavior (gene expression). Responses to cytokines include increasing or decreasing expression of membrane proteins (including cytokine receptors), proliferation and secretion of effector molecules.

b. Discuss briefly what you understand by the compliment system as was discussed in class (5 PTS)

The complement system is a group of more than 30 plasma and membrane proteins that play a critical role in host defence. When activated, complement components interact in a highly regulated manner to generate products that Recruit inflammatory cells (promoting inflammation), Opsonize microbial pathogens and immune complexes (facilitating antigen clearance), Kill microbial pathogens (via a lytic mechanism known as the membrane attack complex) and Generate an inflammatory response. Complement activation takes place on antigenic surfaces. However, the activation of complement generates several soluble fragments that have important biologic activity.