UNIT
10

IMMUNOLOGY

Edward Jenner,

Edward Jenner, an English Physician and Scientist, is known as the Father of Immunology because of his contribution to the invention of a vaccine against small pox which saved many lives.

RI591

Learning Objectives

After studying this chapter, one should be able to

- Understand the basic concepts of infection.
- Identify few infectious diseases.
- Understand the differences between innate and adaptive immunity.
- List out the functions of antibodies.
- Carry out blood grouping tests

10.1. INTRODUCTION TO IMMUNOLOGY

"A healthy life is a wealthy life" and "Prevention is better than cure" are the proverbs frequently used to define the status of human health which is closely related to immunity and the immune system. Immunity is defined as the state of resistance to disease caused by specific microorganism or their toxic products. The immune system is the system of specialized cells and organs that protect an organism from diseases and infectious organisms. It is also called as the host defense system. Immunology is the study of all aspects of the immune system in an organism.

The concept of immunity can be traced back to 430BC, when Thucydides observed that individuals who had recovered from the plague would not get it a second time and could nurse other affected patients. The earliest recognised and written evidence of inducing immunity was practiced by the Chinese and Turks in the 15th Century. They either inhaled the dried crusts derived from small pox pustules or inserted them into wounds in the skin. Lady M.W. Montagu, the wife of the British ambassador to Constantinople, applied this technique on her own children and found the results to be positive. In 1798, a vaccine (from the Latin word 'vacca' , meaning 'cow') for small pox was developed by Edward Jenner. He inoculated an 8-year old boy James Phipps with material obtained from a cowpox lesion. The results were conclusive of prevention of small pox infection. Friedrich Henle was the first to discover that germs caused disease and the isolation of infectious bacteria was done by his pupil Robert Koch. Louis Pasteur developed vaccine for chicken cholera, anthrax and rabies. Modern immunology begins with the research of Metchnikoff, who discovered the phenomenon of phagocytosis in starfish and extrapolated it to macrophages in humans as cells that engulf infectious agents.

Variolation was the method used to immunize individuals against smallpox by infecting them with substance from the pustules of patients.

10.2. INFECTION

Infection is defined as the invasion and multiplication of pathogenic organisms in the host. An infection without symptoms is represented as subclinical; and with symptoms it is represented as clinically apparent. Illness caused through pathogenic organisms is termed as infectious disease or communicable disease or transmissible disease.

Epidemiology

Epidemiology is the branch of medical science that deals with the geographical distribution and timing of infectious disease occurrences. The study also includes the modes of transmission and maintenance in nature, with the goal of recognizing and controlling outbreaks.

The spectrum of occurrence or prevalence of disease in a defined population includes sporadic, endemic, epidemic and pandemic.

Sporadic refers to a disease that occurs infrequently and irregularly without a geographic focus. Examples of sporadic diseases include tetanus, rabies, and plague.

Endemic disease is an infectious disease which is restricted to a population in a given geographical region only and the constant rate of presence for years.

Epidemic refers to an increase in the number of cases of a disease in a particular geographical region within a short span of time when compared to the previous year infection rate. Influenza (common cold) is a good example of a common epidemic disease.

Pandemic refers to an epidemic that has spread over several countries or continents, usually affecting a large number of people i.e. a wide geographical region. AIDS is an example for pandemic since it is present in many countries.

Transmission

Transmission of an agent causing an infectious disease can be direct or indirect. The transfer of an infectious agent directly into the body is known as direct transmission. There are four types of **direct contact transmission**.

1. **Physical contact** between hosts (Influenza, Skin infections).
2. **Direct contact** with body fluids or tissues of an infected individual (HIV, HPV).
3. **Droplet contact** in which large infectious particles sprayed into the air from the respiratory tract of an infected individual (pneumonia, mumps, measles).
4. **Droplet nuclei contact** in which small infective dried droplet particles that are suspended in the air are taken in by a host, and are capable of traveling to the lung (TB, chickenpox).

Indirect transmission is the transfer of a pathogen by a vector or vehicle. Malaria is an example of a vector borne disease. Examples of diseases spread through vehicle-borne transmission are food-borne diseases and waterborne diseases eg: Cholera. Zoonosis occurs when diseases are transferred from animals to people. Zoonotic diseases include anthrax from sheep and plague from rodents.

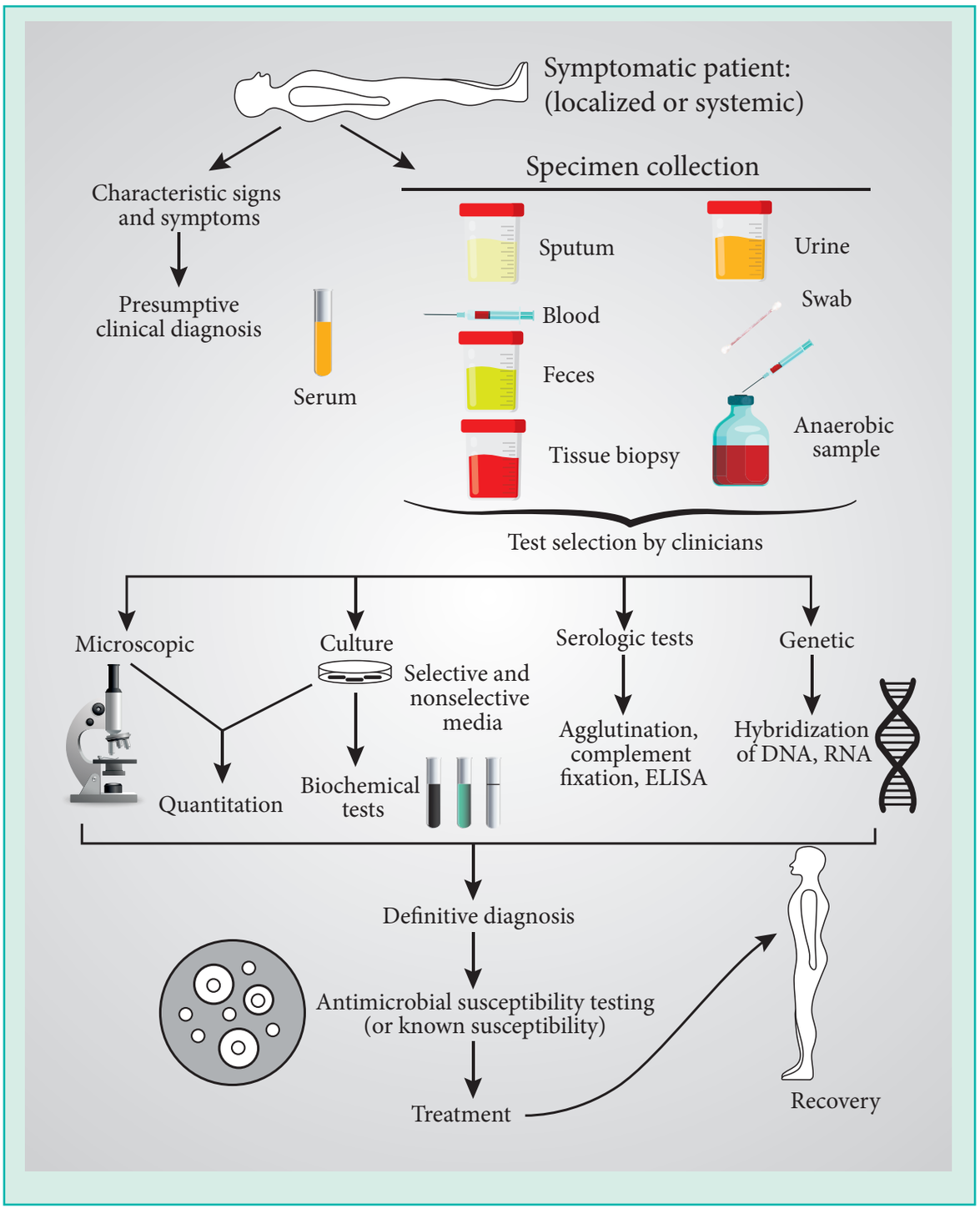
Etiology

Etiology is the study of cause or origin of disease. The etiologic agent or causative agent is responsible for the cause of a disease. A pathogen or infectious agent is a biological agent that causes disease or illness to its host organism. Pathogenic organisms are of five major types - bacteria, virus, fungi, worms, and protozoa.

Diagnosis

Laboratory tests may identify organisms directly (e.g., visually, using a microscope, growing the organism in culture) or indirectly (e.g., identifying antibodies to the organism). They use a sample of blood, urine, sputum, stool, throat swab or other fluid or tissue from

the infected individual. This sample may be stained and examined under a microscope, cultured, tested for antibodies, tested for a microorganism's antigens or tested for genetic material (such as DNA or RNA) from the microorganism.



Treatment and Prevention

Antibiotics, anti-virals, anti-fungals, and anti-parasitic agents along with quorum quenching methods are being used to treat infectious diseases depending upon the nature of infection. Many infectious diseases can be prevented by personal hygiene and vaccines.

Pus is a thick protein rich fluid called as liquor puris. It consists of dead white blood cells and infected agents. It is a natural product formed during immunological reactions against infecting agents. It might be yellow or green or brown in colour and with foul odour. Appearance of pus at the site of surgery indicates an infection.

10.2.1. Bacterial Infections

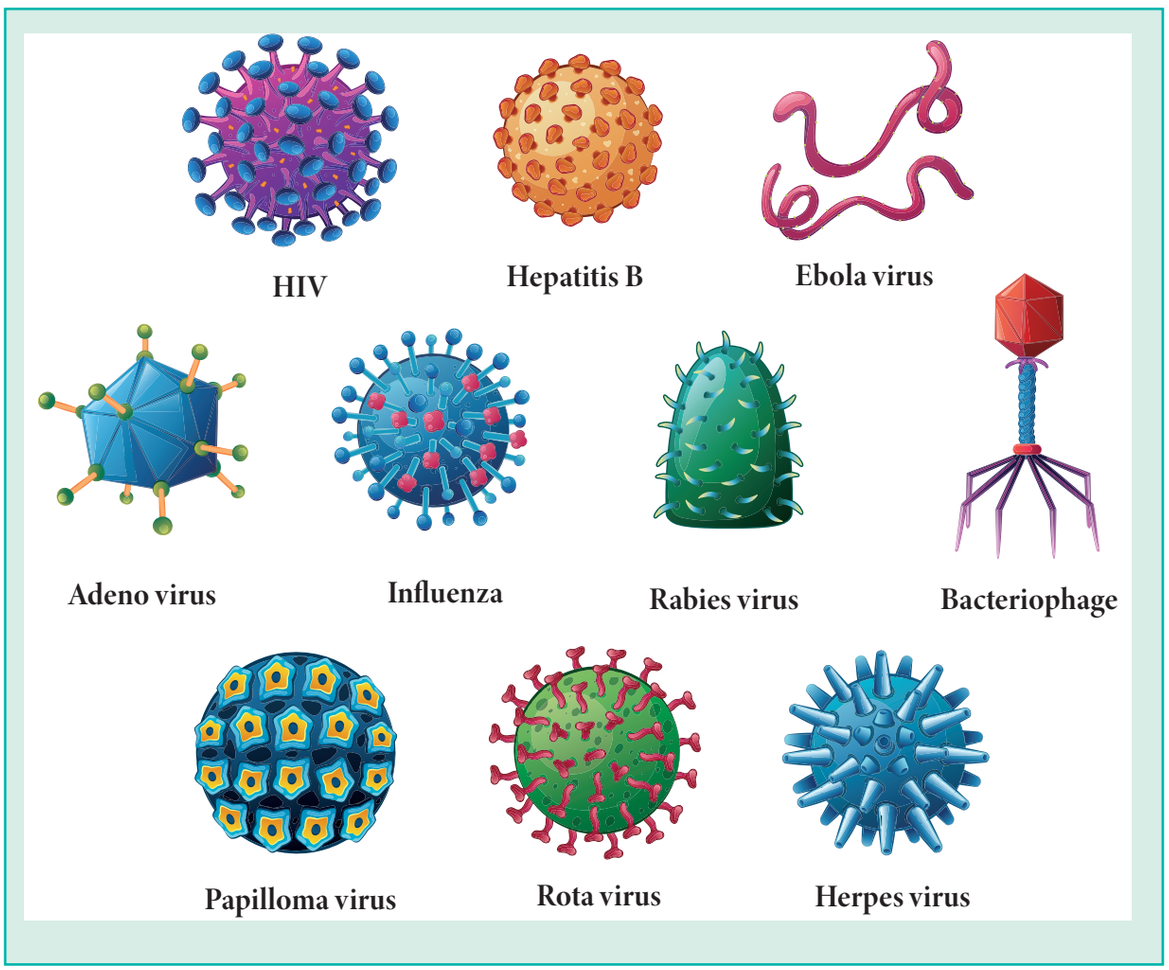
Bacterial infections include any type of illness caused by bacteria. Based on the structure and shape,there are three major groups of bacteria namely, Bacillus (cylindrical forms), Coccus (spherical forms) and Spiral. Humans and animals have abundant normal flora (microbes) that usually do not produce disease under normal healthy condition. These bacteria are referred to as good bacteria or healthy bacteria or normal flora. Harmful bacteria that cause bacterial infections and disease are called pathogenic bacteria. Bacterial diseases occur when pathogenic bacteria enter into the body and begin to reproduce and to grow in tissues that are normally sterile. Harmful bacteria may also emit toxins that can damage the body.

Name of Disease	Pathogen	Mode of transmission	Incubation Period	Symptoms	Therapy
Pulmonary Tuberculosis	*Mycobacterium tuberculosis*	Airborne and Droplet infection	2-10 weeks	Coughing; chest pain and bloody sputum	Streptomycin, para-amino salicylic acid, rifampicin
Diphtheria	*Corynebacterium diphtheriae*	Airborne and Droplet infection	2-6 days	Inflammation of mucosa of nasal chamber, throat etc. respiratory tract blocked	Diphtheria antitoxins, Penicillin, Erythromycin
Cholera	*Vibrio cholerae*	Direct and oral with contaminated food and water	6 hours to 2 – 3 days	Acute diarrhoea and dehydration	Oral rehydration therapy and tetracycline
Leprosy	*Mycobacterium leprae*	Slowest, infectious and contagious	2-5 years	Skin hypopigmentation, nodulated skin, deformity of fingers and toes.	Dapsone, rifampicin, Clofazimine

Tetanus (Lock Jaw)	*Clostridium tetani*	Through injury	3-21 days	Degeneration of motor neurons, rigid jaw muscles, spasm , paralysis	Tetanus-antitoxins
Plague	*Yersinia pestis*	Indirect and inoculative (vector is rat flea)	2-6 days	Bubonic plague affects lymph nodes; Pneumonic plague affects lungs and Septicemic plague causes anaemia	Tetracycline, streptomycin, Chloromycetin

10.2.2. Viral Infections

Viruses are acellular obligate intracellular parasites. They contain only one type of nucleic acid, it may be either single or double stranded DNA or RNA. Viral diseases range from minor ailments such as the common cold to severe diseases such as Rabies and Acquired Immune Deficiency Syndrome (AIDS). They may be sporadic like Mumps, endemic like Infectious hepatitis, epidemic like Dengue fever or pandemic like Influenza.



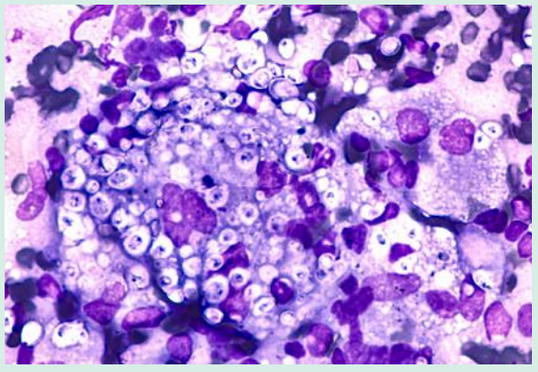
Name of disesae	Pathogen	Mode of transmission	Incubation period	Symptoms	Therapy
Poliomyelitis	Polio-virus	Direct and oral	7-14 days	Damages motor neurons causing stiffness of neck, convulsion, paralysis of generally legs	Physiotherapy
Measles	Rubella-virus	Contagious and Droplet infection	10 days	Rubeola (skin eruptions), coughing, sneezing	Antibiotics and sulpha drugs
Mumps	Mumps-virus	Contagious and Droplet infection	12-26 days	Painful enlargement of parotid salivary glands	Antibiotics
Rabies (Hydrophobia)	Rabies-virus	Indirect and inoculative	10 days to 1- 3 months	Spasm of throat and chest muscles, fears from water, paralysis and death	Pasteur-treatment
Influenza (Flu)	Myxovirus influenzae	Air borne and pandemic	24-48 Hours Lasts for 4-5 days	Bronchitis, sneezing bronchopneumonia, leucopenia, coughing	Antibiotic therapy
Hepatitis (Epidemic Jaundice)	Hepatitis-B virus	Direct and oral	20-35 days	Damage to liver cells releasing bilirubin, jaundice	Hepatitis-B vaccine
Chikungunya	chikungunya virus	infected *Aedes aegypti* mosquitoes (vector)	3 weeks	rash, muscle pain, fever and severe joint pain	Antipyretics, analgesics, fluids, and rest
Dengue fever	*Dengue virus*	infected *Aedes aegypti and Aedes albopictus* mosquitoes (vector)	3 to 14 days	Fever, Headache, Rash appearing between the second and fifth day of fever, Platelets reduction	Intravenous (IV) fluids, acetaminophen

AIDS	Human Immuno deficiency Virus (HIV)	Direct contact with infected blood, semen or vaginal fluids	12 years	flu-like symptoms such as fever, sore throat and fatigue after few weeks of infection	anti-retroviral treatment (ARVT)

10.2.3. Fungal Infections

Fungi are eukaryotic protista, recognized as causative agents of human disease earlier than bacteria. Fungal infections (mycosis) are most common among those patients who use antibiotics for prolonged period of time. These antibiotics not only kill pathogenic bacteria but also target the normal flora of human body (useful bacteria) and give rise to fungal growth. Human fungal infections are usually of two types: superficial and deep infection. Fungi causing superficial mycoses are specialized saprophytes, with the capacity to digest keratin. Superficial mycoses are of two types - surface infections (only on dead layers of skin) and cutaneous infections (cornified layer).

Mucormycosis molds



Histoplasma fungi

Disease Name	Pathogen	Mode of transmission	Symptoms	Therapy
Candidiasis or yeast infections	*Candida* yeasts *Candida albicans*	Direct contact	itching and swelling, redness and soreness	Nystatin , Clotrimazole and fluconazole
Jock itch or Tinea cruris (Dermatophytoses)	*Trichophyton rubrum* and *T. mentagrophytes*	direct contact with an infected person	redness in the groin, buttocks, or thighs, itching	miconazole, clotrimazole, ketoconazole

Athlete's foot or Tinea pedis (Dermatophytoses)	*T. mentagrophytes, Trichophyton rubrum*	Direct contact	redness or blisters, peeling or cracking skin	topical antifungal ointments, itraconazole, terbinafine
Tinea capitis or scalp ringworm (Dermatophytoses)	*Trichophyton tonsurans, T. schoenleinii, T. violaceum*	Direct contact	round patches of dry scale, alopecia	Griseofulvin, Terbinafine
Mucormycosis	*Mucor and Rhizopus*	Air borne	Opportunistic pathogen	Amphotericin B

10.3 IMMUNITY

Immunity refers to the ability of the immune system to defend against diseases caused by microbes or foreign substances which are products like toxins from microbes. Immunity depends upon various factors like host resistance, dosage of organism injected and virulence of the organisms.

10.3.1. Classification

Immunity is mainly classified into innate and acquired immunity. Innate or nonspecific or natural immunity refers to the basic resistance to disease that an individual is born with. Acquired or specific or adaptive immunity requires the activity of a functional immune system, involving cells called lymphocytes and their products. Innate defense mechanisms provide the first line of defense against invading pathogens until an acquired immune response develops. In general, most of the microorganisms encountered by healthy individual are readily cleared within a few days by non-specific defense mechanisms without enlisting a specific immune response. When an invading microorganism eludes the nonspecific host defense mechanism, a specific immune response occurs.

10.3.1.1. Innate (Natural) Immunity

Innate immunity may be considered at the level of the species, race or individual. Species immunity refers to the total or relative refractoriness to a pathogen, shown by all members of a species. For instance, all human beings are totally insusceptible to plant pathogens and to many pathogens of animals such as rinderpest.. This immunity is something a person obtains by birth, for the reason that he belongs to the human species. The mechanisms of species immunity may be due to physiological and biochemical differences between the tissues of the different host species, which determine whether or not a pathogen can multiply in them.

Within a species, different races may show differences in susceptibility to infections. This is known as racial immunity. It has been reported that the African-descendants in the USA are more susceptible to tuberculosis than the Americans. The differences in innate immunity exhibited by different individuals in a race are known as individual immunity. It is well documented that homozygous twins exhibit similar degrees of resistance or susceptibility to lepromatous leprosy and tuberculosis.

10.3.1.2. Components involved in Innate Immunity

Components involved in innate immunity include skin, mucus, cells like neutrophils, macrophages, natural killer cells and soluble factors like complements, cytokines, and acute phase proteins.

Skin and mucus provide anatomical barrier, cells like macrophages and neutrophils provide phagocytic barrier and soluble factors like complement, acute phase proteins provides physiological and inflammatory barriers.

10.3.1.3 Mechanisms involved in Innate immunity

Innate immunity is provided by four types of defensive barriers namely, anatomical, physiological, phagocytic and inflammatory barriers.

Anatomical Barriers

Anatomic barriers that tend to prevent the entry of pathogens are an organism's first line of defense against infection. The skin and the surface of mucous membranes are included in this category because they are effective barriers to the entry of most microorganisms. The outer epidermis of skin contains several layers of tightly packed epithelial cells which prevents entry of pathogens. The outer epidermal layer consists of dead cells and is filled with a waterproofing protein called keratin. The inner dermis layer of skin, which is composed of connective tissue, contains blood vessels, hair follicles, sebaceous glands, and sweat glands. The sebaceous glands are associated with the hair follicles and produce an oily secretion called sebum. Sebum consists of lactic acid and fatty acids, which maintain the pH of the skin between 3 and 5; this pH inhibits the growth of most microorganisms.

The conjunctivae, the alimentary, respiratory, and urogenital tracts are lined by mucous membranes. These membranes consist of an outer epithelial layer and an underlying layer of connective tissue. The viscous fluid called mucus, which is secreted by epithelial cells of mucous membranes, entraps foreign microorganisms. In the lower respiratory tract, the mucous membrane is covered by cilia, the hair like protrusions of the epithelial cell membranes. The synchronous movement of cilia propels mucus-entrapped microorganisms from these tracts.

Physiological Barriers

The physiological barriers that contribute to innate immunity include temperature, pH, and various soluble and cell associated molecules. Many species are not susceptible

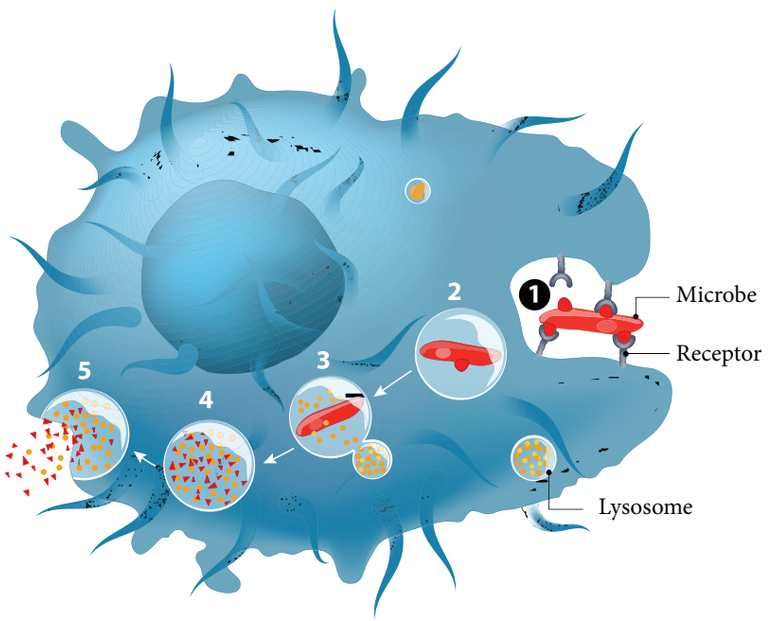
to certain diseases simply because their normal body temperature inhibits growth of the pathogens. Gastric acidity is an innate physiologic barrier to infection because very few ingested microorganisms can survive the low pH of the stomach contents.

A variety of soluble factors contribute to innate immunity, among them are the soluble proteins lysozyme, interferon, and complement. Lysozyme, a hydrolytic enzyme found in mucous secretions and in tears, is able to cleave the peptidoglycan layer of the bacterial cell wall. Interferon comprises a group of proteins produced by virus-infected cells which prevents viral infection of neighbouring cells. Complements lyse bacteria by forming membrane attack complex.

The newborn babies (neonates) are susceptible to some infections that do not affect adults. The reason is that their stomach contents are less acidic i.e higher pH than those of adults. The pH variation provides optimum medium for the growth of pathogenic microorganisms.

Phagocytic Barriers

Another important innate defense mechanism is the ingestion of extracellular particulate material by phagocytosis. The process of phagocytosis was discovered by Metchnikoff. The term phagocytic denotes the engulfment and digestion of whole cells. The two major cell types in the body which are associated with the engulfment and digestion of microorganism are the polymorphonuclear leucocytes and the macrophages. Minor cell types are the eosinophils. The process of phagocytosis involves the following steps:



1. Binding and absorption
2. Phagosome formation
3. Phagosome and lysosome fuse to form a phagolysosome
4. Digestion
5. Release of microbial products

1. Attachment

   Attachment is the adherence of a bacterium to the cell membrane of the phagocytic cell. Some bacteria are easily attached to the phagocytic cell. Example , *Mycobacterium tuberculosis*.

2. Phagosome formation

   After attachment the phagocyte extend small pseudopodia around the infecting bacterium. The pseudopodia fuse to form an endosome which contains a bacterium surrounded by the cell membrane. This structure is called as phagosome.

3. Phagolysosome formation

   After engulfment, the lysosome containing the hydrolytic enzymes fuses with phagosome to form phagolysosome. In this step, lysosomal enzymes are discharged to phagosome which is vital for the lysis of bacteria.

4. Lysis

   A number of antimicrobial and cytotoxic substances produced by phagocytes can destroy phagocytosed microorganisms.

Oxygen dependent killing mechanisms

During phagocytosis, a metabolic process known as the 'respiratory burst' occurs in activated phagocytes. This process results in the activation of a membrane bound oxidase that catalyzes the reduction of oxygen to superoxide anion, a reactive oxygen intermediate that is extremely toxic to ingested microorganisms. Activated phagocytes begin to express high levels of nitric oxide synthase (NOS), an enzyme that oxidizes L-arginine to yield L-citrulline and nitric oxide (NO). Much of the antimicrobial activity of phagocytes against bacteria, fungi, parasitic worms, and protozoa is due to nitric oxide and substances derived from it.

Oxygen independent killing mechanisms

Activated phagocytes also synthesize lysozyme and various hydrolytic enzymes whose degradative activities do not require oxygen. In addition, activated phagocytes produce a group of antimicrobial and cytotoxic peptides, commonly known as defensins. Cathepsin G is an example for defensins. These molecules are cysteine-rich cationic peptides that form circularized defensin which inturn form ion-permeable channels in bacterial cell membranes to lyse bacteria. Lactoferrin chelates iron from the medium and prevents the growth and proliferation of iron dependent bacteria. Lysozyme splits mucopeptide in bacterial cell wall and lysed bacteria.

5. Exocytosis

   Finally the killed organisms are digested by hydrolytic enzymes and the degraded products are released to the exterior by the process of exocytosis.

Inflammatory Barriers

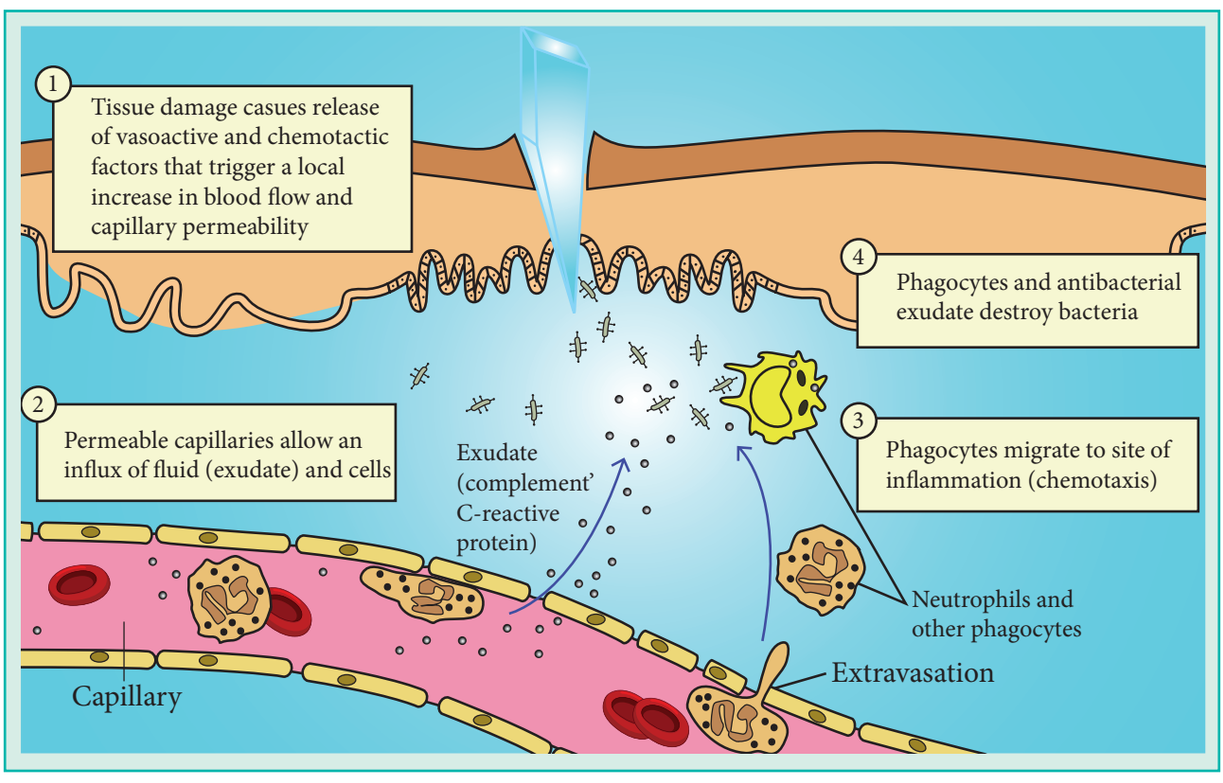
This barrier is created by the inflammatory response. Tissue damage caused by a wound or by an invading pathogenic microorganism induces a complex sequence of events collectively known as the inflammatory response. Inflammatory response is described by the "four cardinal signs of inflammation" as rubor (redness), tumor (swelling), calor (heat) and dolor (pain). Presently a fifth sign, functio laesa (loss of function),is included.

The following are the sequential steps that occur during inflammation:

Vasodilation occurs in nearby capillaries resulting in enlargement of the capillary network. The enlarged capillaries are responsible for tissue redness (erythema) and an increase in tissue temperature.

An increase in capillary permeability facilitates an influx of fluid and cells from the enlarged capillaries into the tissue. The fluid that accumulates (exudate) has much higher protein content than fluid normally released from the vasculature. Accumulation of exudate contributes to tissue swelling (edema).

Influx of phagocytes from the capillaries into the tissues is facilitated by the increased permeability of the capillaries. The emigration of phagocytes is a multistep process that includes adherence of the cells to the endothelial wall of the blood vessels (margination), followed by their emigration between the capillary endothelial cells into the tissue (diapedesis or extravasation), and finally, their migration through the tissue to the site of the invasion (chemotaxis). As phagocytic cells accumulate at the site and begin to phagocytose bacteria, they release lytic enzymes, which can damage nearby healthy cells. The accumulation of dead cells, digested material, and fluid forms a substance called pus.



Inflammation that develops at the site of infection induces the acute phase response. This generalized response is characterized by fever, changes in vascular permeability and changes in biosynthesis, metabolism and catabolism in many organs. These changes result in a rise in the concentration of certain proteins in the blood and a drop in the concentration of other proteins. These proteins that are elevated termed as acute phase proteins or acute phase reactants. These include C- reactive protein (CRP), fibrinogen and serum amyloid A protein. The concentration of CRP in the blood increases from a normal level of 1 mg / ml to as much as 1000 mg / ml during the acute phase response. It functions in clearance of nuclear material released from killed microbes and killed host cells during inflammation by binding to DNA, chromatin and histones.

10.3.2. Acquired (Adaptive) Immunity

The form of immunity that is mediated by lymphocytes and stimulated by exposure to infectious agents is adaptive immunity. It reflects the presence of a functional immune system that is capable of specifically recognizing and selectively eliminating foreign microorganisms and molecules. It is characterized by four characteristics namely antigenic specificity, diversity, immunologic memory, and self and non-self recognition.

Antigenic specificity

Immune responses are directed toward and able to distinguish between distinct antigens or small parts of macromolecular antigens. This fine specificity is attributed to lymphocyte antigen receptors that may bind to one molecule but not to another with only minor structural differences from the first. Antibodies can differentiate between two molecules that differ by only a single aminoacid.

Diversity

Diversity is the result of variability in the structure of the antigen binding sites of lymphocyte receptors for antigens. Diversity allows the adaptive immune system to specifically recognize billions of uniquely different structures on foreign antigens.

Immunologic memory

Immunologic memory is mediated by memory cells. Memory cells are clonally expanded progeny of T and B cells formed during the primary response following initial exposure to antigen. Memory cells are more easily activated than naive lymphocytes and mediate secondary response on subsequent exposure to antigen. They survive in a functionally quiescent state for many years, even after the elimination of the antigen. Due to this attribute, the immune system can confer life long immunity to many infectious agents.

Self and non-self recognition

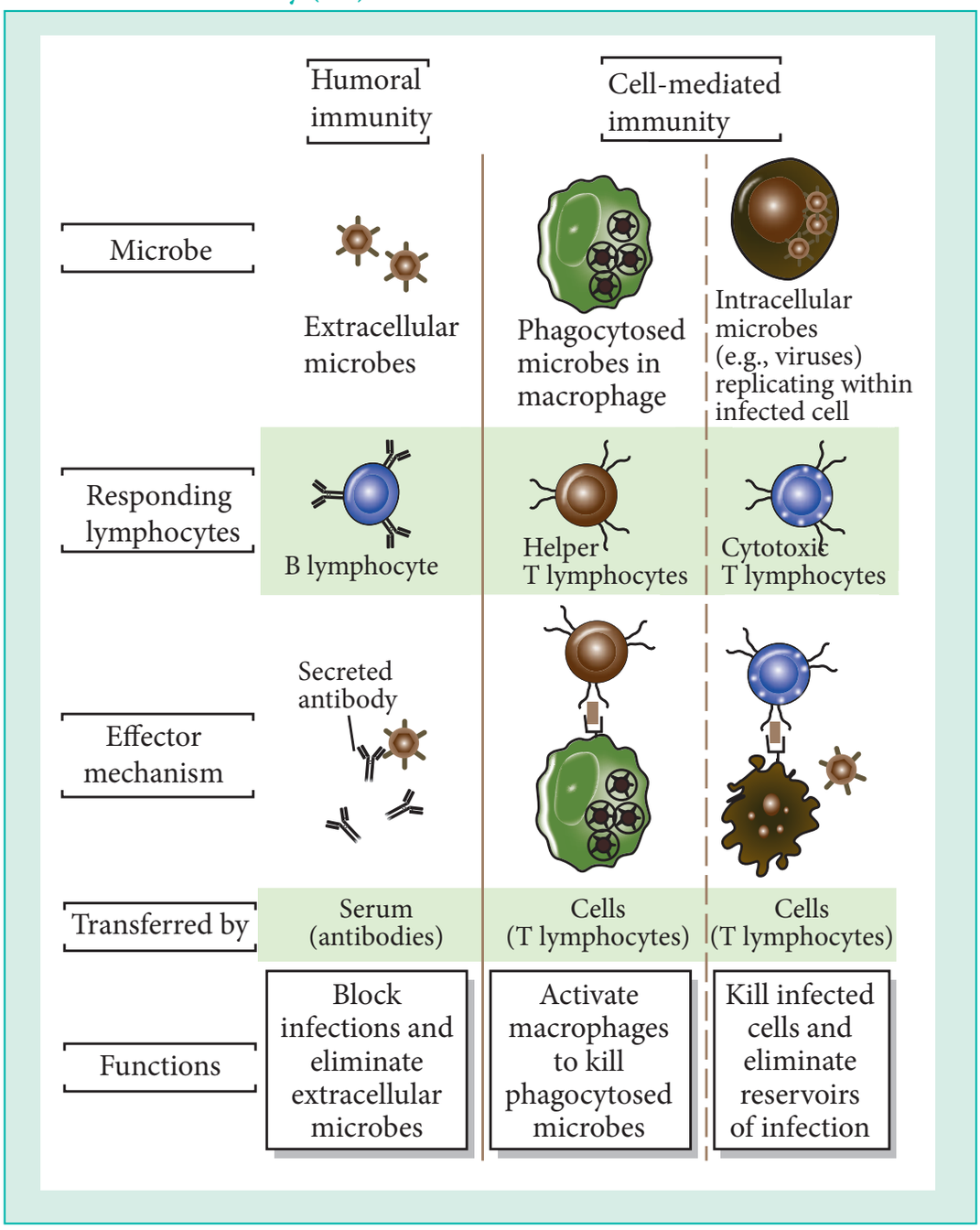
The immune system is able to distinguish self (host) from nonself (foriegn) antigens and respond only to non-self molecules. The production of immune cells only against non- self molecules, is achieved by selection procedure like positive selection and negative

selection during the maturation process of lymphocytes in bone marrow and thymus.

Acquired immunity does not occur independent of innate immunity and vice versa. For example, the phagocytic cells crucial to nonspecific immune responses are intimately involved in activation of the specific immune response. Similarly, the soluble factors produced during a specific immune response have been shown to augment the activity of these phagocytic cells.

Acquired immunity, on the basis of components involved in immunity is classified into two types namely, Humoral immunity and Cell mediated immunity.

10.3.2.1 Humoral Immunity (HI)



The term humoral is derived from the Latin word humor meaning "body fluid". Thus humoral immunity refers to immunity that can be conferred on a non-immune individual by administration of serum antibodies from an immune individual. Humoral immunity is mediated by molecules in blood and mucosal secretions containing antibodies that are produced by cells called B lymphocytes.

Antibodies recognize microbial antigens, neutralize infectivity of the microbes and target microbes for elimination by various effector mechanisms. Antibodies themselves are specialized and different types of antibodies may activate by different mechanisms, for example, IgG and IgM antibodies promote phagocytosis and IgE antibodies trigger the release of inflammatory mediators from leukocytes such as mast cells. Binding of antibody to antigen on a microorganism also can activate the complement system, resulting in lysis of the microbes.

Humoral immunity is the principal defense mechanism against extracellular microbes and their toxins because secreted antibodies can bind to these microbes and toxins and assist in their elimination.

10.3.2.2 Cell Mediated Immunity (CMI)

Cell Mediated immunity (cellular immunity) is mediated by T lymphocytes. There are two types of T-cells mainly TH and TC which differ by their surface marker CD4 and CD8, respectively. T-cells are activated by antigen presenting cells (APC) after processing antigens. Both activated TH cells and TC cells serve as effector cells in CMI. Cytokines secreted by TH cells can activate various phagocytic cells, enabling them to phagocytose and kill microorganisms more effectively. Cytotoxic T lymphocytes (CTL) participate in CMI by killing altered self cells. They also play an important role in the killing of virus infected cells and tumor cells.

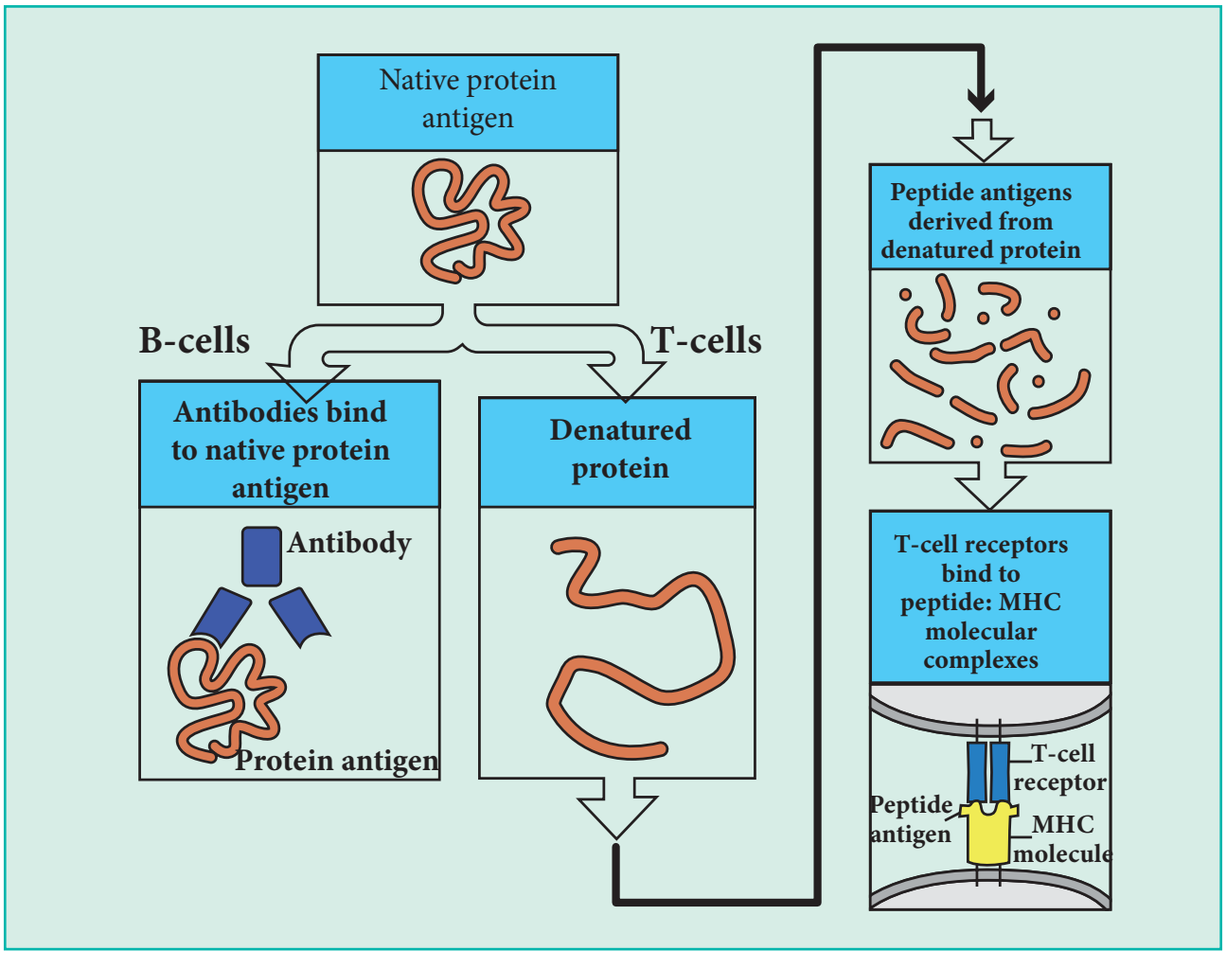
Intracellular microbes such as virus and some bacteria survive and proliferate inside phagocytes and other host cells, where they are inaccessible to circulating antibodies. Defense against such infections is a function of cell mediated immunity.

Antigen presenting cells are a functionally defined group of cells which are able to take up antigens and present them to T lymphocytes. Eg: Dendritic cells, activated macrophages, and activated B-cells.

A collective and coordinated response to the introduction of foreign substances in an individual, mediated by the cells and molecules of the immune system is referred to as immune response. An adaptive immune response that occurs upon the first exposure of native lymphocytes with a foreign antigen is known as primary immune response. An adaptive immune response that occurs upon the second or subsequent encounter of primed lymphocytes with a given antigen is known as secondary immune response.

10.4. ANTIGENS

Antigens are foreign substances that have an ability to induce antibody generation. Antigenic determinant or epitope is the region of the antigen recognized by antibodies or T-Cell Receptor (TCR) of T cells. There are two types of epitopes namely B cell epitope and T cell epitope. B cell epitope is the region of antigen recognized by antibodies. T cell epitope is the region of antigen recognized by TCR of T cells.



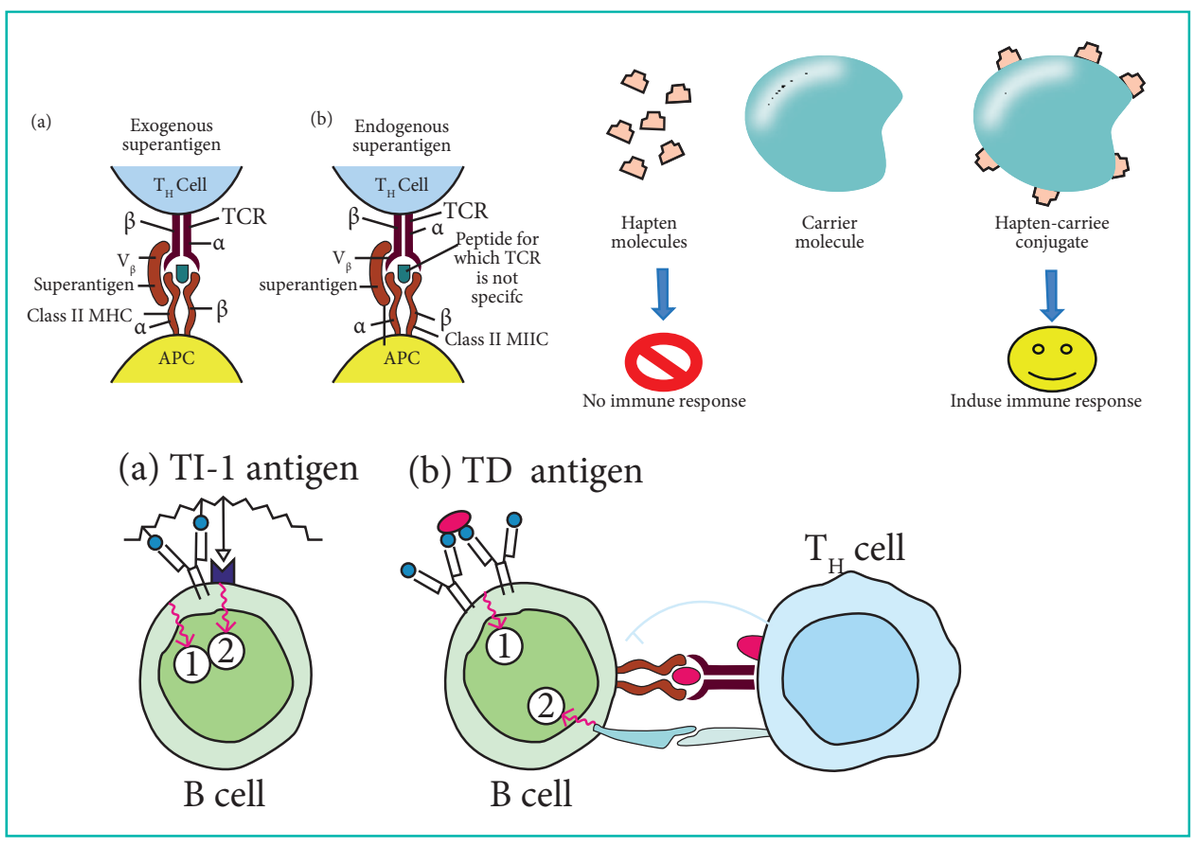
10.4.1. Types of antigens

Sl. No.	Types of Antigens	Nature	Example
1.	Sequestered antigens	These antigens are secluded or sequestered in capsule i.e. it is not exposed to immune system during development or when produced.	Lens proteins and sperm proteins.
2.	Neoantigens	They are newly produced antigens i.e. normal agents become antigens. They are formed due to the change in the chemical, physical and biological status of the agents.	Penicillin can be converted to neoantigen when it is bound with protein.

3.	Heterophile or Heterogenic or Cross reactive antigen	These antigens interact with antibodies produced against another antigen.	Forssman antigen. These antigens are present on mucosal cells of GI tract of human and RBCs of horse.
4.	Mitogenic antigens	Since some mitogens (they induce cell division) activate immune cells, they can be considered as mitogenic antigens.	Lipopolysaccharides induce B cell proliferation, Concanavalin – A (CON A) and Phytohemagglutinin (PHA) induce T cell proliferation and Pokeweed mitogen (PWM) induces both T and B cell proliferation.
5.	Superantigens	These antigens activate T cells non-specifically.	TSST-1 (Toxic shock syndrome toxin – 1) produced from *Staphylococcus sp*. . - Exogenous superantigens Mouse mammary tumor viral (MMTV) antigens - Endogenous superantigens
6.	Exogenous antigens	These antigens are usually secretory products of microbes or soluble antigens. They are usually present outside the host cell	Diphtheria toxin from *Cornebacterium diptheriae*
7.	Endogenous antigens	They are usually microbes which are present inside the cell or particulate antigen.	Virus and endotoxins

Sl. No.	**Types of Antigens**	**Nature**	**Example**
8.	T cell dependent antigens	These antigens require T cells especially T_H cells to induce immune response.	Soluble antigens

9.	T cell independent antigens	These require T cells partially or not to induce immune response. T cell independent antigen – I (TI-1) does not require T cell to induce immune response. T cell independent antigen – 2 (TI-II) does not require direct contact of T cells but cytokines produced by them to induce immune response.	Lipopolysaccharides – Example for TI-I Cell wall polysaccharides and glycoproteins – Example for TI-II.
10.	Allergens	Antigens responsible for allergic response are called allergens.	Pollens
11.	Autogens	Those antigens which are capable of inducing autoimmune disorders are known as autogens.	Immunoglobulins for Rheumatoid Arthritis.
12.	Self antigens	They are not originally antigens. They are normal cell surface components and proteins of normal host.	Host proteins
13.	Haptens	Haptens are otherwise known as incomplete antigens or partial antigens because they are unable to elicit immune response by itself, but they can gain this ability when they bind with a carrier molecule.	Dinitrophenol (DNP)



10.4.2. Factors influencing the antigenicity of antigens

Ability of an antigen to induce an immune response is known as antigenicity. The factors that influence antigenicity are mainly of two types i.e. factors contributed by antigens and factors contributed by host cells.

Factors contributed by Antigens:

The factors are: size, foreignness, chemical nature, complexity, heterogeneity and susceptibility for antigen processing.

Size

Antigens with greater than 10,000 Daltons molecular weight are found to be effective antigens. For example: Hemoglobin is more antigenic than penicillin.

Foreignness (Alien)

It refers to the distance in the phylogenetic tree i.e. evolutionary distance. Highly distant organisms are found to have more antigenicity than less distant ones. For example: Protein from gorilla is found to have less antigenicity than the protein from fish to humans because fish is more evolutionarily distant from gorilla.

Chemical Nature

Depending on the chemical nature, antigenicity varies.; For example, proteins have greater antigenicity than carbohydrates, lipids and nucleicacids. Solubility also plays an important role. Less soluble antigens have more antigenicity.

Complexity

As the complexity of the antigens increase antigenicity also increases. For example, Primary structure of proteins has lesser antigenicity than tertiary structure of the same protein.

Heterogeneity

In the case of multimeric proteins, heteromultimeric proteins have more antigenicity than homomultimeric proteins. This is mainly because of presence of the different types of epitopes in heteromultimeric proteins.

Susceptibility for Antigen Processing

Those antigens which are found to be easily processed by Antigen Presenting Cells (APCs), have greater antigenicity than those antigens which are not easily processed. For example: Horse RBCs have greater antigenicity than asbestos.

Factors contributed by Host

These factors include route of entry, genotype and dose.

Route of entry

Route of entry is also important to provide antigenicity and disease. If a microorganism enters through an adverse route, it is degraded by the immune mechanism and is less antigenic. When it enters through its natural route, it will cause disease and it also escapes from the immune system partially. For example: *Vibrio cholerae* entering through the circulatory system will not cause diarrhea; but if it enters through GI tract, it causes diarrhea.

Genotype

The genetic constitution (genotype) of an immunized animal influences the type of immune response the animal manifests, as well as the degree of the response. For instance, human beings are protected against some diseases, yet affected by other diseases. It purely depends upon the genotype.

Dose

To induce antigenicity, an optimum amount of infecting agent or antigen is required and this optimum amount is known as optimum dose. When microbes enter above and below this optimum dose level, fluctuation occurs in antigenicity.

10.5. ANTIBODIES (IMMUNOGLOBULINS)

Antibodies are proteins secretedby B-cells. Antibodies combine chemically with substances which the body recognizes as alien, such as bacteria, virus, and foreign substances in the blood.

Antibodies protect the host against potential parasites by:

1) directly inhibiting binding sites of virus or various enzymes and toxins produced by bacteria,
2) agglutination,
3) opsonization which facilitates removal by phagocytes,
4) lysis of susceptible organisms via complement fixation, and
5) inducing inflammation.

10.5.1. Antibody structure

Antibodies are classified into five types. They are IgG, IgA, IgM, IgD and IgE.

The general structure of antibodies are explained with the example of IgG. The IgG molecule is composed of two identical heavy (H) chains and two identical light (L) chains. The H and L chains are linked by disulfide bridges.

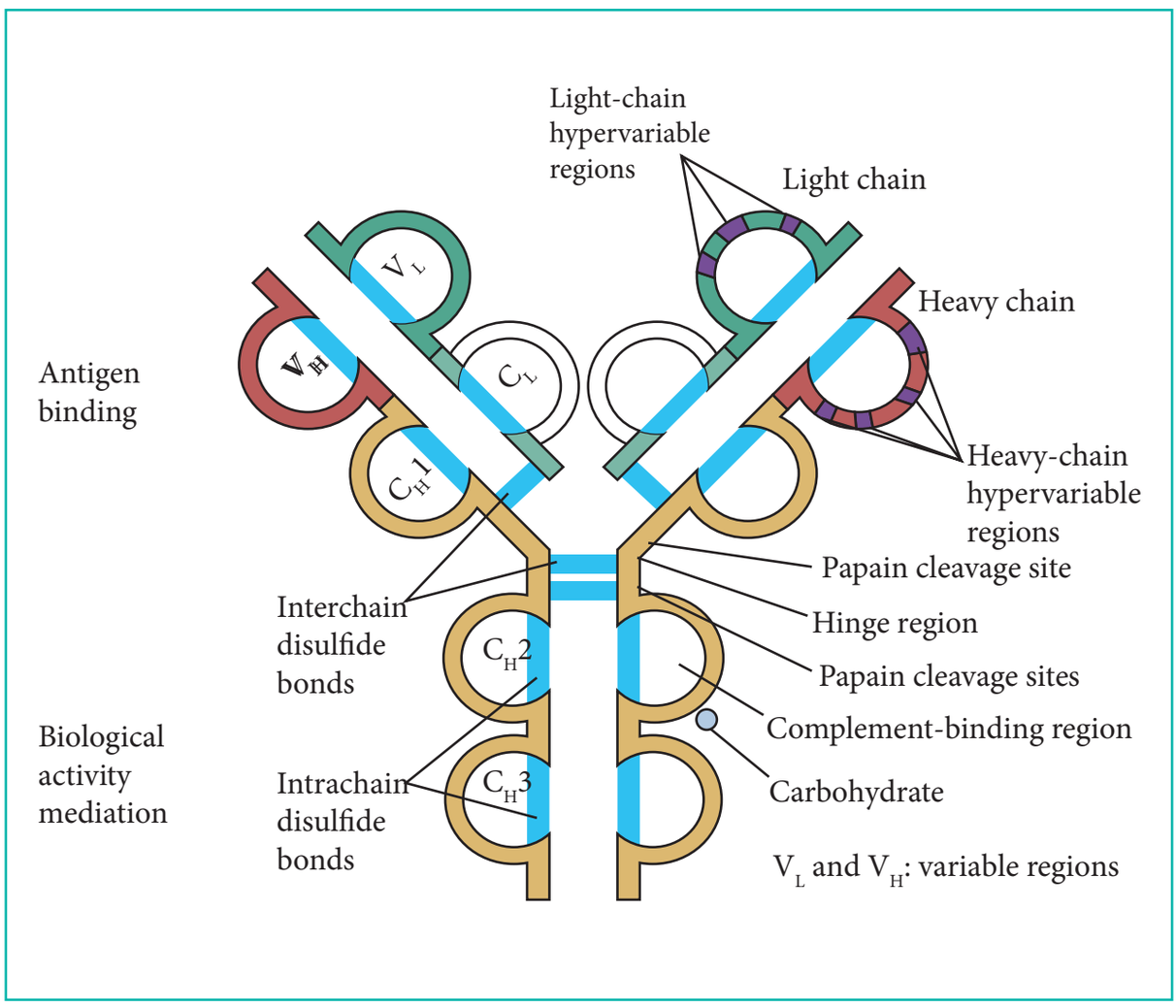
The H chain contains four or five domains. Each domain of immunoglobulin molecule consists of 110 amino acid residues. The amino terminal of heavy chain , shows great sequence variation to other antibodies for different antigens and was therefore called the variable (V) region. The remaining part of the heavy chain is called as constant (C) region. Each of the different heavy chain constant region sequences is called an isotype. The

length of the constant region is approximately 330 amino acids for gamma (IgG), delta (IgD) and alpha (IgA) and 440 amino acids for mu (IgM) and epsilon (IgE). In humans there are two subclasses of alpha heavy chains and four subclasses of gamma chains .

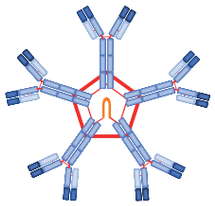
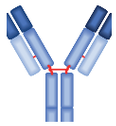
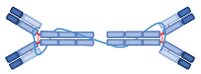
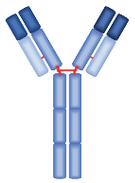
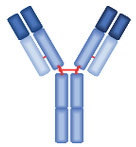
Light chain domain consisting of 110 amino acids was found to have varying amino acid sequences in different antibodies for different antigens at amino terminal end. This region was called as the variable (V) region. The carboxy terminal half of the molecule, is called the constant (C) region. There are two types of light chains , kappa and Lambda . In humans 60% of the light chains are kappa and 40% are lambda. A single antibody molecule contains either kappa chains or lambda chains, but never both.

The gamma, delta, and alpha heavy chains contain an extended peptide sequence between the C_{H1} and C_{H2} domains. This region, called the hinge region**,** is rich in proline residues and is flexible.

A paratope (antigen-binding site) is a part of an antibody which recognizes and binds to an antigen. It is a small region of the antibody's variable region, and contains parts of the antibody's V_H domain of heavy and V_L domain of light chains. This region is also called as complementarity determining region (CDR).



10.5.2. Types of Antibodies - Classification

The Five Immunoglobulin(Ig) Classes					
	IgM Pentamer	IgG Monomer	Secretory IgA Dimer	IgE Monomer	IgD Monomer
			 Secretory Component		
Heavy chains	μ	γ	α	ε	δ
Number of antigen binding sites	10	2	4	2	2
Molecular weight (Daltons)	900000	150000	385000	200000	180000
Percentage of total antibody in serum	6%	80%	13%	0.002%	1%
Crosses placenta	No	Yes	No	No	No
Fixes complement	Yes	Yes	No	No	No
Fc binds to		Phagocytes		Mast cells land basophils	
Function	Main antibody of primary responses, best at fixing complement, the monomer form of IgM serves as the B cell receptor.	Main blood antibody of secondary responses, neutralizes toxins, opsonisation	Secreted into mucus, tears, Saliva, Colostrum	Antibody of allergy and antiparasitic activity	B Cell receptor

10.6 ANTIGEN-ANTIBODY REACTIONS

Antigen-Antibody reactions refer to the interaction between antigens and antibodies. The reactions between antigens and antibodies occur in three stages.

The primary stage is the initial interaction between antigen and antibody without any visible effects.

The secondary stage leading to demonstrable events such as precipitation, agglutination, lysis of cells, killing of live antigens, neutralization of toxins and other biologically active antigens, fixation of complement, immobilization of motile organisms and enhancement of phagocytosis.

The tertiary stage reactions lead to neutralization or destruction of antigens which might lead to tissue damage. They include humoral immunity against infectious disease as well as clinical allergy and other immunological disease.

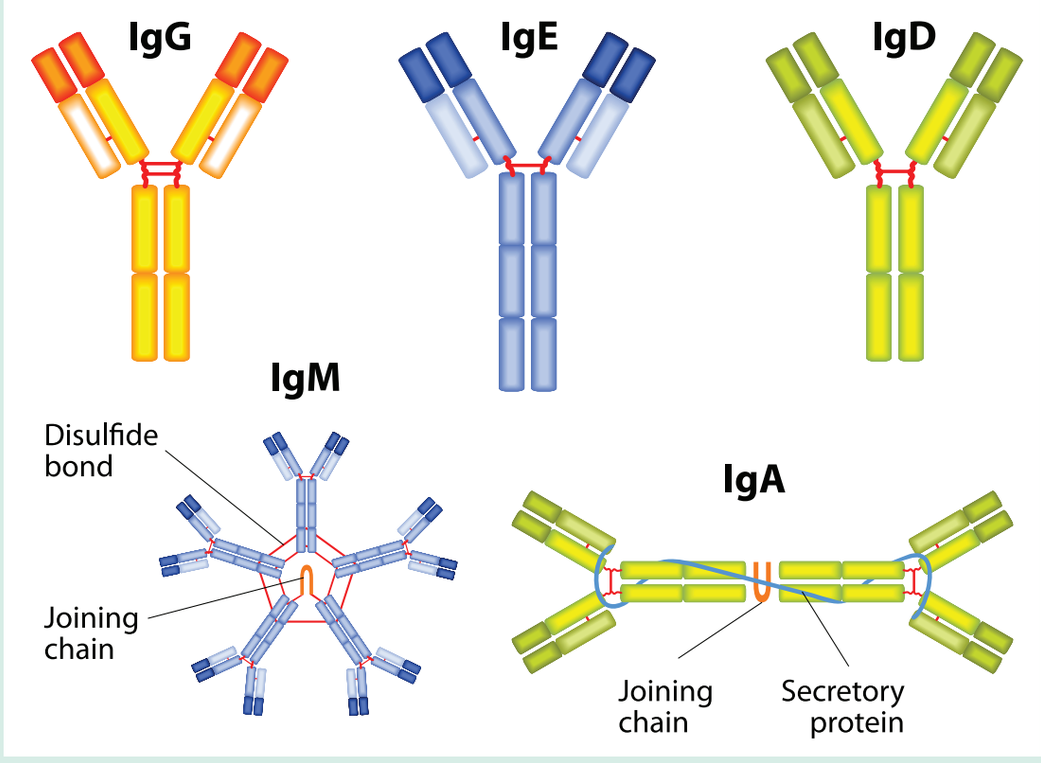
Antigen-antibody reactions have the following general characteristics:

1. The reaction is specific. However cross reaction may occur.
2. Entire molecules react and not fragment.
2. There is no denaturation of the antigen or the antibody during the reaction.
3. The combination occurs at the surface.
4. The combination is firm but reversible. The firmness of the union is influenced by the affinity and avidity of the reaction.

Affinity refers to the intensity of attraction between single epitope of the antigen and paratope of antibody molecules.

Avidity is the total strength of the bond after the formation of the antigen antibody complexes. Generally IgG possess greater affinity and IgM possess higher avidity

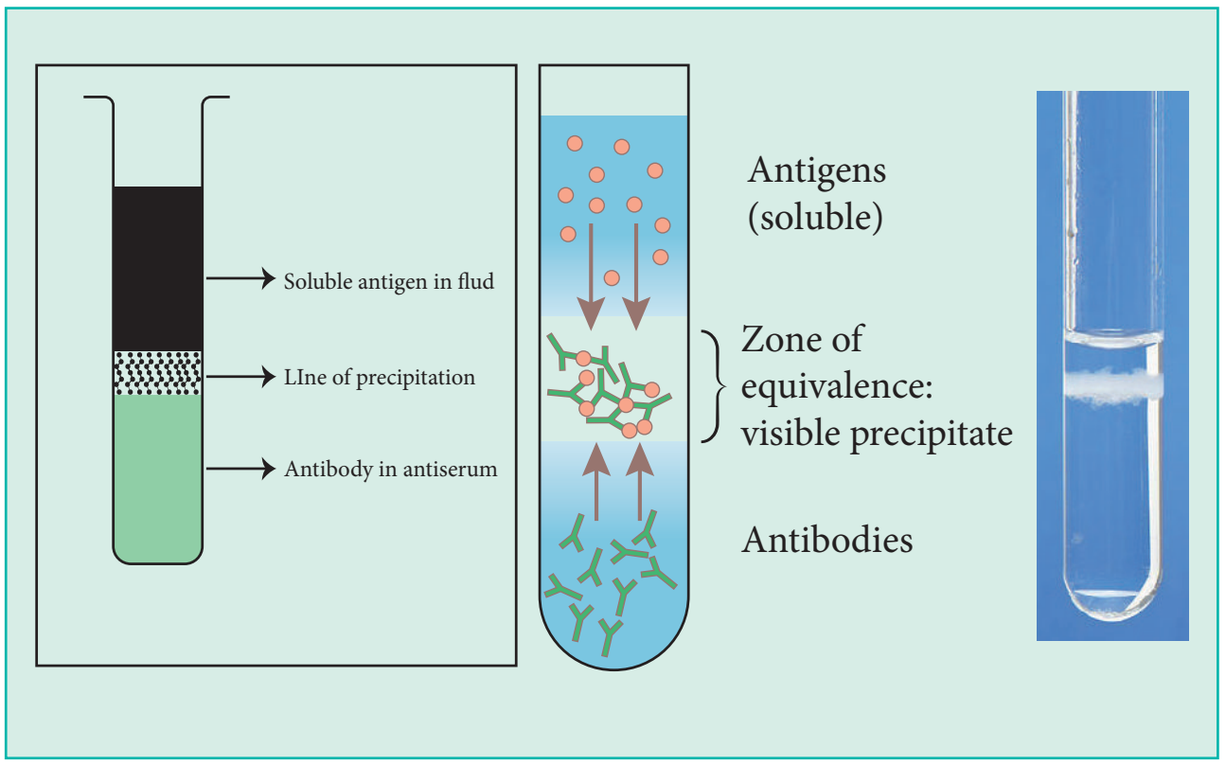
5. Both antigen and antibodies participate in the formation of agglutinates or precipitates.
6. Antigens and antibodies can combine in varying proportions.



10.6.1. Precipitation

The interaction between an antibody and a soluble antigen in aqueous solution forms a lattice that eventually develops a visible precipitation. Antibody that forms precipitation is known as precipitin. This process is called as precipitation reaction. Formation of an Ag-Ab lattice depends on the valency of both antigen and antibody. Zone of equivalence is a point at which the maximum precipitation occurs. This reaction is widely used in several immunological techniques.

Ring test: In this test, over a column of antiserum (antibody), the antigen solution is layered. A precipitate forms at the junction of the two liquids.



10.6.2. Agglutination

The interaction between antibody and a particulate antigen results in visible clumping called agglutination. Antibodies that produce such reactions are called agglutinins. Agglutination reactions are similar in principle to precipitation reactions; they depend on the cross linking of polyvalent antigens. Just as an excess of antibody inhibits precipitation reactions, such excess can also inhibit agglutination reactions; this inhibition is called the prozone effect.

Haemagglutination (Slide Agglutination)

In typing for the ABO antigens, RBCs are mixed on a slide with antisera to the A or B blood-group antigens. If the antigen is present on the cells, they agglutinate, forming a visible clump on the slide. Determination of which antigens are present on donor and recipient RBCs is the basis for matching blood types for transfusions. At neutral pH, red blood cells are surrounded by a negative ion cloud that makes the cells repel one

another.This repulsive force is called zeta potential. Because of its size and pentameric in nature, IgM can overcome the zeta potential and cross link red blood cells, leading to agglutination. The smaller size and bivalency of IgG makes it less able to overcome the zeta potential. For this reason, IgM is more effective than IgG in agglutinating red blood cells.

Bacterial Agglutination (Tube Agglutination)

A bacterial infection often elicits the production of serum antibodies specific for surface antigens on the bacterial cells. The presence of such antibodies can be detected by bacterial agglutination reactions.

Widal test is used for the diagnosis of typhoid fever. In typhoid patients, the serum contains antibodies to *Salmonella typhi*. In Widal test, two antigens are used. They are antigen H, the flagellar antigen and O antigen, the somatic antigen. When antiserum of the patient is added to the antigens, the antigens are clumped and identified.

Antiglobulin Test (Coombs Test):

The antiglobulin test was devised by Coombs, Mourant and Race for the detection of anti-Rh antibodies that do not agglutinate Rh positive erythrocytes in saline. When sera containing incomplete anti-Rh antibodies are mixed with Rh positive red cells, the antibody globulin coats the surface of the erythrocytes, though they are not agglutinated. When such erythrocytes coated with the antibody globulin are treated with a rabbit antiserum against human gammaglobulin (antiglobulin or Coombs serum), the cells are agglutinated. This is the principle of the antiglobulin test.

10.7. BLOOD GROUPS

A blood type is a classification of blood, based on the presence and absence of antibodies in blood and inherited antigenic substances on the surface of red blood cells. These antigens may be proteins, carbohydrates, glycoproteins, or glycolipids, depending on the blood group system.

10.7.1. ABO System

Karl Landsteiner discovered ABO blood group system. He was awarded Noble Prize in 1930 for his discovery. The membranes of human red cells contain a variety of blood group antigens,which are also called **agglutinogens.** The most important and best known of these are the A and B antigens. Antibodies against red cell agglutinogens are called **agglutinins.** Antibody-A and Antibody-B are examples of agglutinins. Landsteiner law states that if an agglutinogen is present on the RBC of an individual, the corresponding agglutinin must be absent in the plasma of that individual and vice-versa.

There are four main blood groups defined by the ABO system:

Blood group A people have A antigens on the red blood cells with anti-B antibodies in the plasma. Blood group B people have B antigens with anti-A antibodies in the plasma

Blood group O people have no antigens, but both anti-A and anti-B antibodies in the plasma. Blood group AB people have both A and B antigens, but no antibodies

Rh System

Another group of antigens found on the red blood cells of people is the Rh factor (Rhesus monkey, in which these antigens were first discovered). The Rh blood group system was discovered in 1940 by Karl Landsteiner and A.S. Weiner. It is the second most important blood group system, after the ABO blood group system. There are five different antigens (C, D, E, c and e) in this group, but D antigen predominantly presents and is medically important. Thus Rh antigen is always referred to as the Antigen-D. If this Rh antigen is present on a person's red blood cells, the person is Rh positive; if it is absent, the person is Rh negative.

Thus the common major blood group systems are of eight blood groups:

A RhD positive (A+)

A RhD negative (A-)

B RhD positive (B+)

B RhD negative (B-)

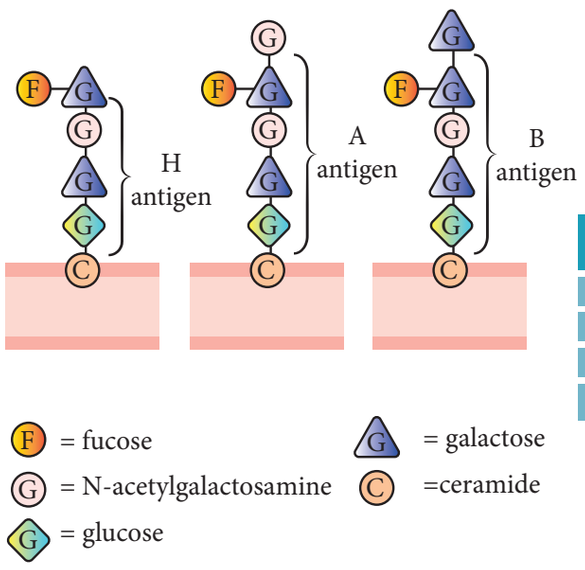
O RhD positive (O+)

O RhD negative (O-)

AB RhD positive (AB+)

AB RhD negative (AB-)

10.7.2. Antigens and Natural antibodies of ABO blood groups



Genotype	Antigen on RBCs	Antibody in Plasma
I^AI^A, I^Ai	A	Anti-B
I^BI^B, I^Bi	B	Anti-A
ii	O	Anti-A and anti-B
I^AI^B	AB	Neither anti-A and anti-B

Each person inherits two genes (one from each parent) that control the production of the ABO antigens. The genes for A or B antigens are dominant to the gene for O. The O gene is recessive, simply because it does not code for either the A or the B red blood cell antigens. The genes for A and B are often shown as I^A and I^B and the recessive gene for O is shown as the lowercase i. A person who is type A, therefore, may have inherited the A gene from each parent (I^A I^A), or the A gene from one parent and the O gene from the other parent (I^Ai). Likewise, a person who is type B may have the genotype I^BI^B or I ^{B}i. It follows that a type O person inherited the O gene from each parent , whereas a type AB person inherited the A gene from one parent and the B gene from the other (I^A I^B).

The immune system exhibits tolerance to its own red blood cell antigens. People who are type A, for example, do not produce anti-A antibodies. However, they do make antibodies against the B antigen and, conversely, people with blood type B make antibodies against the A antigen. This is believed to result from the fact that antibodies made in response to some common bacteria present in the gut (normal flora) which are similar to A or B antigens. People who are type A, therefore, acquire antibodies that can react with B antigens by exposure to these bacteria, but they do not develop antibodies that can react with A antigens because tolerance mechanisms prevent this. People who are type AB develop tolerance to both of these antigens, and thus do not produce either anti-A or anti-B antibodies. Those who are type O, by contrast, do not develop tolerance to either antigen; therefore, they have both anti- A and anti-B antibodies in their plasma.

Isoantibodies: Iso means belonging to the same species. Isoantibody is an antibody produced by one individual that reacts with the antigen of another individual of the same species. Antibody – A and Antibody– B are called Isoantibodies. Both of these anti-A and anti-B antibodies are of Ig M type. Rh antibody (Antibody - D) is of Ig G type.

Isoantigens: An antigen of an individual which is capable of eliciting an immune response in individuals of the same species who are genetically different and who do not possess that antigen is called isoantigen. It is also otherwise known as alloantigens. A-Antigen and B-Antigen are examples of isoantigens.

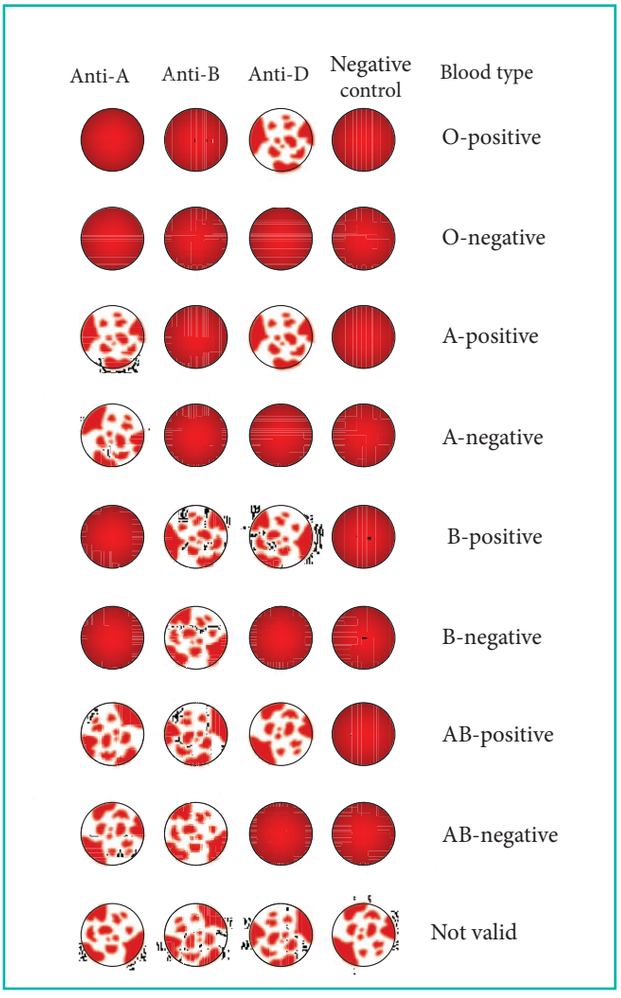
Natural antibodies: Humans form antibodies against the blood group antigens they do not express.These antibodies are called naturally occurring antibodies or isoagglutinins. Antibody production starts at 3 months of age, reaches its highest level during adult and decreases with advancing age.

Test Procedure

Basically, a sample of blood is mixed separately with anti-A antibodies, anti-B antibodies and Rh antibodies. If the red cells clump together with anti-A antibodies, then it indicates the presence of A antigens in the red blood cells and the person belongs to A group. Similarly, if agglutination reaction occurs with anti-B antibodies then it indicates the presence of B antigen.

When agglutination is found in both anti-A and anti-B antibodies it indicates that the person belongs to AB group. If no agglutination is found with both antibodies of A and B

then it indicates the absence of antigens and the person belongs to O group. Similarly if an anti-Rh antibody shows agglutination with the given blood then it indicates the presence of Rh antigens on the blood cells. Hence the person is Rh positive. If no agglutination is seen then the person is Rh negative.



Activity 10.1

Prepare the flow chart of the history of immunology

Activity 10.2

Cut an apple in half. Cover one half of the apple with food wrapper and leave the other half uncovered. Using a dropper, release several drops of food coloring on each half of the apple. Answer the following questions: What happened to the uncovered half of the apple and to the covered half? How does the food wrapper provide a model of the human skin?

Activity 10.3 Creating Personal Health Record

You can check on the status of your health habits by creating a personal health record for your own use.

Taking Care of Your Immune System

S.No.	Activities
1.	Eat a well-balanced and healthy diet.
2.	Get plenty of exercise and rest.
3.	Brush your teeth and bathe or shower regularly
4.	Keep your home clean.
5.	Avoid tobacco, drugs and alcohol.
6.	Get vaccinations that prevent diseases.

Do the following activities: Look at the list of behaviors in the table above. Write each of the behaviors at the top of a separate piece of paper. Write down your habits related to each behavior during a typical week. Do you think that your weekly habits are healthy?

Activity 10.4

On a separate sheet of graph paper, graph the data of antibody production given below. You should assume that on 0th day, the body was invaded by an unknown antigen. Then you can also assume that the person was exposed for a second time to the same antigen on day 40.

Time	Antibody Units	Time	Antibody Units	Time	Antibody Units	Time	Antibody Units
0	0	16	80	32	0	48	150
4	10	20	20	36	0	52	300
8	70	24	24	40	0	56	260
12	120	28	0	44	40	60	200

Answer the following questions from the graph:

How does the first part of the graph (days 0-28) compare to the second part of the graph (days 28-60)?

Which do you think is the response being made by the memory cells?

Summary

The immune system protects the host from infectious agents. Entry, survival and proliferation of pathogenic microbes are referred to as infections. Bacterial, viral and fungal pathogens predominantly cause infectious diseases. Recovery from these infections is naturally achieved with the help of the natural defence system of the host , that is the immune system. The ability of the immune system to protect the host from infections is known as immunity.

There are two major types of immunity, namely innate and acquired immunity. Innate immunity is a type of immunity obtained by birth, but it is non-spectific in its action. Innate immunity is provided by four barrier systems namely anatomical, physiological, phagocytic and inflammatory barriers.

Acquired immunity is a specific type of immunity which is provided by immune cells like T-Cells, B-Cells, K-Cells, NK-Cells etc., and immune components like antibodies. Acquired immunity is further divided into humoral immunity and cell mediated immunity. Antibodies play a vital role in humoral immunity. Immune cells like T-Cells play a vital role in cell mediated immunity.

Antigens are foreign substances which have an ability to induce production of immune response products.Depending upon their nature and origin, there are about thirteen different types of antigens. Antigenic determinant or epitope is the region of the antigen recognized by antibodies or T-Cell Receptor (TCR) of T cells. The ability of an antigen to induce an immune response is known as antigenicity. The factors that influence antigenicity are mainly of two types i.e. factors contributed by antigens and factors contributed by host cells.

Antibodies are proteins produced by B cells in response to a specific antigen. The IgG molecule is composed of two identical heavy (H) chains and two identical light (L) chains. There are about five isotypes of antibodies namely Ig G, Ig M, Ig A, Ig E and Ig D. The H and L chains are linked by disulfide bridges. Antigen-Antibody reactions refer to the interaction between antigens and antibodies.

The interaction between an antibody and a soluble antigen in aqueous solution forms a lattice that eventually develops a visible precipitation. Antibody that forms precipitation is known as precipitin. The interaction between antibody and a particulate antigen results in visible clumping called agglutination**.** Antibodies that produce such reactions are called agglutinins**.**

A blood type is a classification of blood, based on the presence and absence of antibodies in blood and inherited antigenic substances on the surface of red blood cells. Karl Landsteiner discovered ABO blood group system. The membranes of human red cells contain a variety of blood group antigens**,** which are also called agglutinogens. The most important and best known of these are the Aand B antigens.

Antibodies against red cell agglutinogens are called agglutinins. Antibody-A and Antibody-B are examples of agglutinins. Another group of antigens found on the red blood cells of people is the Rh factor which leads to the determination of the second major blood group system i.e. Rh system. There are eight common types of blood groups in combination of ABO and Rh blood grouping systems. Blood grouping tests are used for avoiding transfusion reactions and transplantation rejections.

EVALUATION

I. Choose the correct Answer

1. Who developed first vaccine for Rabies?

   a. Edward Jenner b. Rober Koch

   c. Louis Pasteur d. Lady Montagu

2. Which one of the following diseases is a pandemic disease?

   a. AIDS b. Common cold

   c. Rabies d. plague

3. Find the suitable vaccine for tuberculosis from the following vaccines:

   a. DPT b. MMR

   c. BCG d. TDP

4. One of the four cardinal sign of inflammatory response “dolor” refers to

   a. Swelling b. Redness

   c. Heat d. Pain

5. Which type of the biomolecule is more antigenic in nature?

   a. Protein b. Carbohydrates

   c. Lipid d. Nucleic acid

6. Name of the protein produced in response to and counteracting a specific antigen from B-cells.

   a. antibody b. Interferon

   c. complement d. acute phase protein

7. What is the name of the region of antibody which recognizes and binds to antigen?

   a. paratope b. agretope

   c. epitope d. none

8. Which test is used for the diagnosis of typhoid fever?

a. Widal test b. ring test

c. tube test d. none

9. Antibodies against red cell agglutinogens are called as _____.

a. precipitin b. agglutinin

c. hapten d. epitope

10. What will be the blood group of a person with the genotype I^BI^B or I^Bi in ABO system?

a. A Group b. B Group

c. O Group d. AB group

11. Who discovered Rh factor?

a. Landsteiner and Weiner b. Louis Pasteur

c. Landsteiner and Koch d. None

12. How many types of constant region of heavy chain identified?

a. 2 b. 3

c. 4 d.5

13. Which one of the following immunity is non-specific in nature?

a. acquired immunity b. humoral immunity

c. innate immunity d. None

14. Name the process carried out by macrophages to lyse bacteria.

a. pinocytosis b. phagocytosis

c. transcytosis d. oxidation

15. What is the alternative name for antiglobulin test?

a. VDRL test b. Cooms test

c. Rabies test d. Koch test

16. Number of antigen binding sites in IgM antibody are

a. 7 b. 8

c. 9 d. 10

17. Which antibody crosses placenta?

a. Ig G b. Ig A

c. Ig M d. Ig E

18. Which type of light chain of antibody predominates?

a. Kappa b. Lamda

c. Gamma d. Alpha

19. What is the average number of amino acids present in a domain of antibody?

a. 440 b. 330

c. 220 d. 110

20. Which one of the following is a superantigen?

a. Autogen b. TSST-1

c. toxoid d. hapten

21. What is the causative agent causing Athlete's foot?

a. Bacteria b. virus

c. fungus d. helminthus

22. The causative agent for AIDS is

a. HPV b. Hepatitis virus

c. HIV d. SV

23. What is the name of the vaccine administered to prevent polio?

a. Salk vaccine b. Sabin vaccine

c. Both a and b d. None

24. Which vaccine used to prevent Tuberculosis?

a. TT b. DPT

c. BCG d. MMR

25. Who is the "Father of Immunology"?

a. Edward Jenner b. Rober Koch

c. Louis Pasteur d. Lady Montagu

II. Match the following

1. Ig G	-	Complement fixation
2. Ig M	-	Colostrum
3. RA Factor	-	Allergy
4. Ig E	-	Opsonisation
5. Ig A	-	Rheumatoid Arthritis

III. Answer the following questions

1. Define epitope
2. What do you meant by phagocytosis?
3. What are haptens?
4. What is the significance of immunologic memory?
5. Give four examples for viral infections.
6. Write short notes on fungal infections.
7. Elaborate the events occuring during inflammatory response.
8. Compare the events of humoral and cell mediated immunity.
9. List out the general characteristics of antigen-antibody reactions.
10. How to identify blood group?
12. Define isoantibodies.
13. What are acute phase proteins?
14. What is the role of tears in immunology?
15. List out minor blood group systems.
16. Explain the tube agglutination test.
17. Define allergen.
18. Define Epidemiology.
19. List out five viral diseases with treatment.
20. Define etiology.
21. Write a note on different diagnostic procedures for infectious disease.
22. What are the different transmission modes of infections?
23. Define variolation.
24. Briefly explain the steps involved in phagocytosis.
25. Differentiate different types of antibodies with a neat table.

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CONCEPT MAP