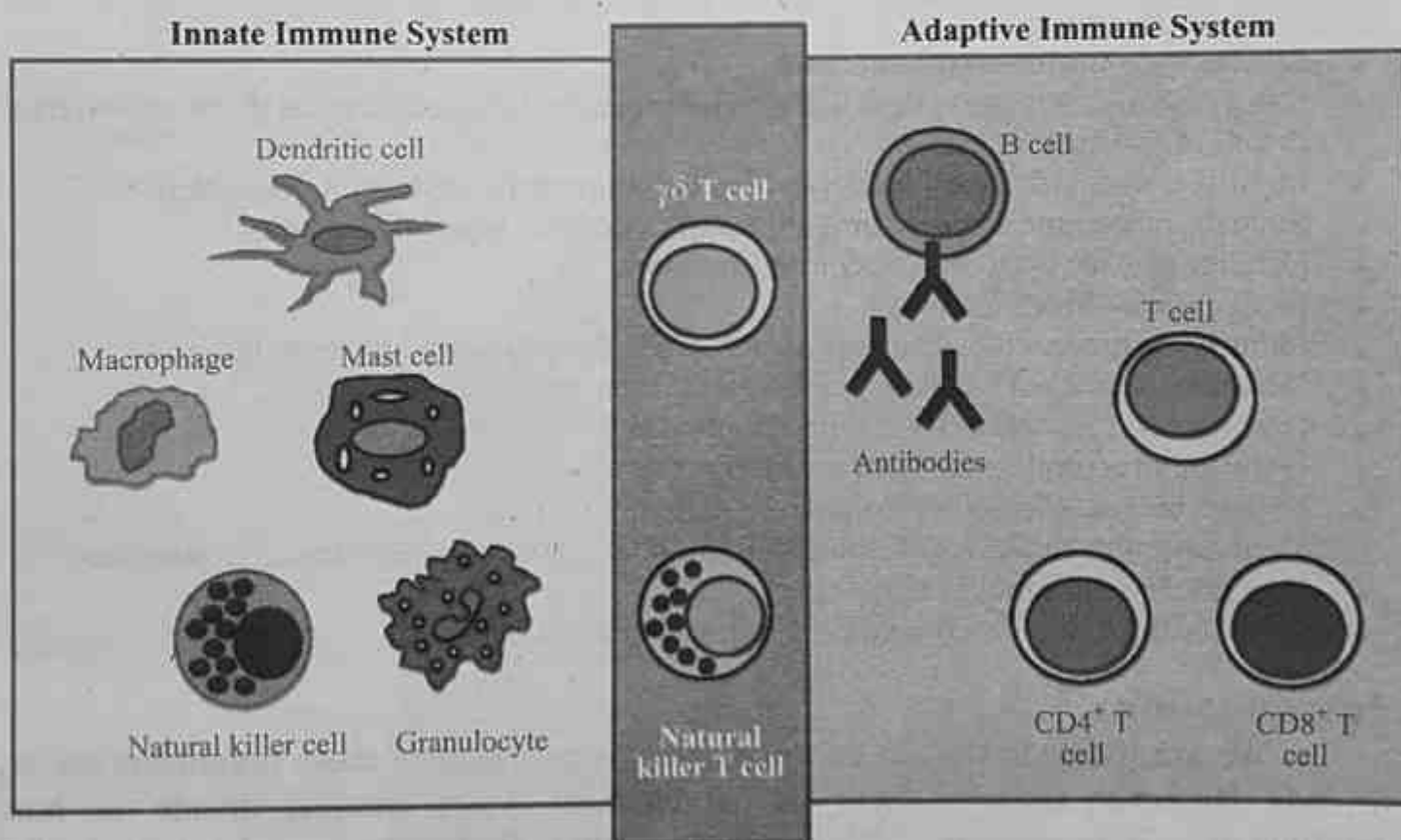


# UNIT 13

## IMMUNITY

### Major Concepts

- 13.1 First Line of Defence.
- 13.2 Second Line of Defence (non specific defence)
- 13.3 Third Line of Defence (The specific defence)



## Students Learning Outcomes

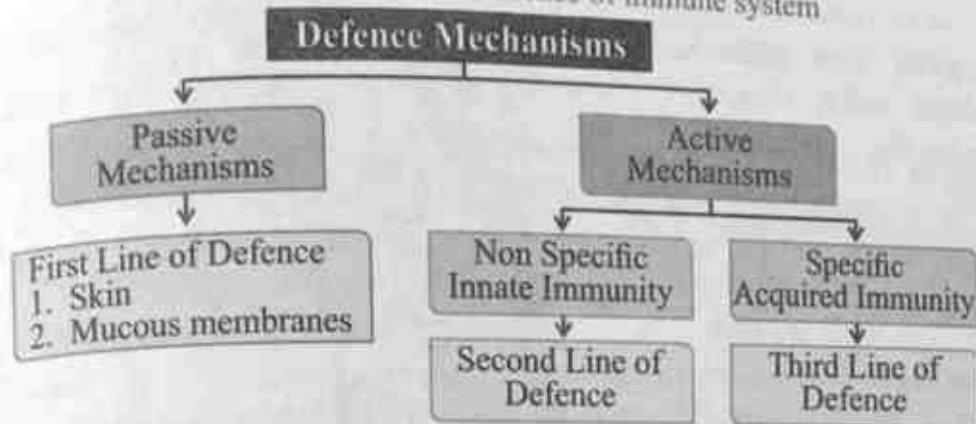
On completion of this unit students will be able to:

- Describe the structural features of human skin that make it impenetrable barrier against invasion by microbes.
- Explain how oil and sweat glands within the epidermis inhibit the growth and also kill microorganisms.
- Recognize the role of the acids and enzymes of the digestive tract in killing the bacteria present in food.
- State the role of the ciliated epithelium of nasal cavity and of the mucous of the bronchi and bronchioles in trapping air borne microorganisms.
- Describe the role of macrophages and neutrophils in killing bacteria.
- Explain how natural killer cells kill the cells that are infected by microbes and also kill cancer cells.
- State how the proteins of the compliment system kill bacteria and how the interferons inhibit the ability of viruses to infect cells.
- State the events of the inflammatory response as one of the most generalized nonspecific defenses.
- Outline the release of pyrogens by microbes and their effect on hypothalamus to boost the body's temperature.
- List the ways the fever kills microbes.
- Categorize the immune system that provides specific defense and act as the most powerful means of resisting infection.
- Identify monocytes, T-cells and B-cells as the components of the immune system.
- State the inborn and acquired immunity as the two basic types of immunity.
- Differentiate the two types of acquired immunity (active and passive immunity).
- Identify the process of vaccination as a means to develop active acquired immunity.
- Describe the roles of T-cells in cell-mediated immunity.
- Describe the role of B-cells in antibody-mediated immunity.
- Draw the structural model of an antibody molecule.
- Explain the role of memory cells in long-term immunity.
- Define allergies and correlate the symptoms of allergies with the release of histamines.
- Describe the autoimmune disease.
- Describe the role of T-cells and B-cells in transplant rejection.

## Introduction

We are living in the sea of micro-organisms. Most of these organisms are our friends. However, some of them are our enemies. These enemies invade our body continuously. To counter attack these invaders, our body has developed a system called **immune system**. The immune system consists of many biological structures and processes within an organism that protects against diseases. This ability of an organism to combat diseases and pathogen is called **immunity**. The study of immunity is called **immunology**. In this chapter we will discuss three lines of defence of immune system.

Table 13.1 Lines of defence of immune system



### 13.1 First Line of Defence (Layered Defence)

The first line of defence is non specific and part of innate immunity (present naturally at the time of birth). It is the best defence as it keeps pathogens out of the body. It consists of following parts.

#### 13.1.1 Skin

Skin is the largest organ of the vertebrate body accounting for 15% of an adult human's total weight. The skin not only defends the body by providing nearly impermeable barrier but also reinforces this defence through chemical weapons on the surface.

#### Tit bits

The word skin is derived from Latin word "cutis". In mammals it is the largest organ of the body. It has many functions like protection, sensation, heat regulation, control of evaporation, excretion etc.

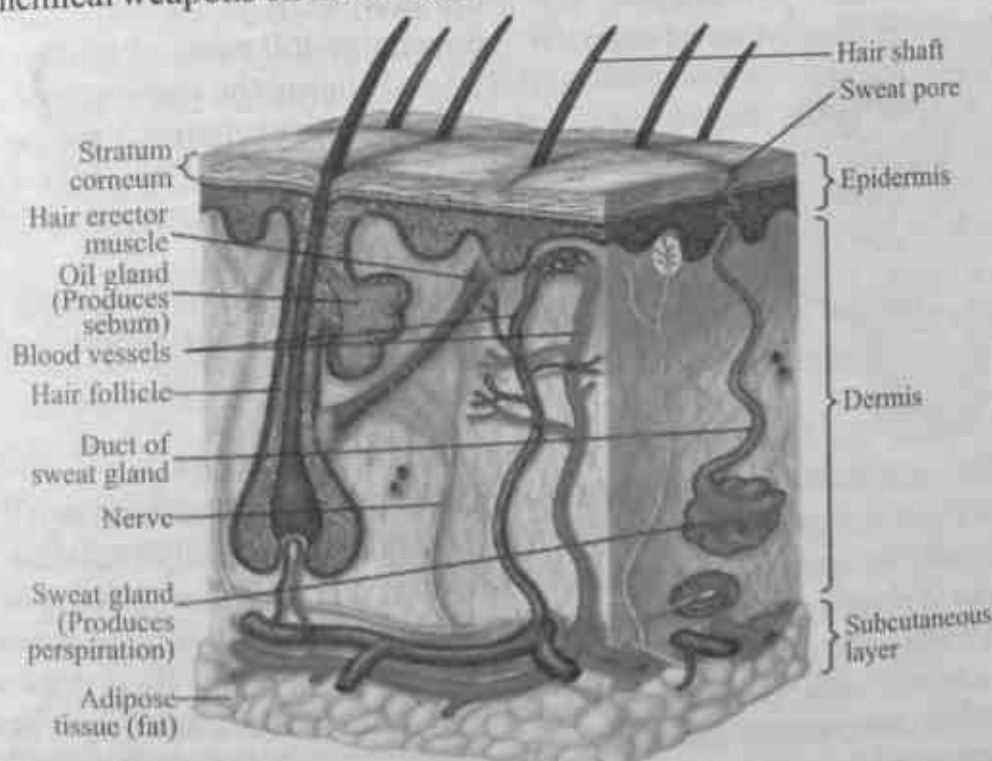


Fig. 13.1 Skin as first line of defence

The skin contains **keratinocytes** and also possesses dead cells, these become barrier for microbes to get entrance.

The dermis of skin produces oil from **sebaceous glands** and sweat from **sweat glands**, gives the skin surface a pH of 3 to 5. It is acidic enough to inhibit the growth of many micro-organisms. Sweat also contains the **lysozymes**, which digest bacterial cell wall. These also contain natural antibiotic (such as lactic acid).

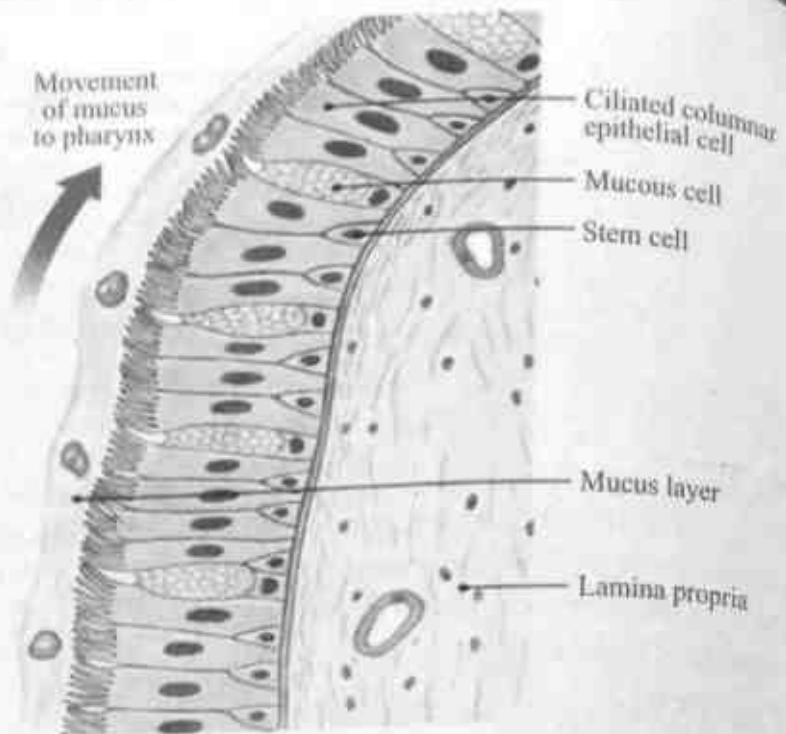


Fig. 13.2 Respiratory Epithelium of Trachea

### 13.1.2 Digestive and Respiratory tract

Both the digestive and respiratory tract open to the outside and their inner surfaces must also be protected by foreign invaders. Microbes are present in food but many are killed by saliva which also contains lysozyme and  $\text{NaHCO}_3$ . The very low pH of stomach due to HCl, enzymes of stomach and intestine kill most of microbes of food. Micro-organisms also present in inhaled air. The cells lining the respiratory tract secrete layer of sticky mucus that traps most of the micro-organisms before they can reach the warm moist lungs, which would provide ideal breeding ground for them. Other cells lining in these passages have **cilia** that continuously sweep the mucus towards the glottis. There it can be either swallowed or spit out.

Occasionally an infectious agent, called a pathogen will enter the digestive and respiratory system and body will use defence mechanisms such as vomiting, diarrhoea, coughing and sneezing to expel the pathogens.

### 13.2 Second Line of Defence: (non specific defence)

This line of defence is also a part of innate immune system. Although the surface defences of the vertebrate body are very effective but occasionally breached allowing invaders to enter the body. At this point the body uses a host of non-specific cellular and chemical devices to defend itself. This type of defence is referred as second line of defence. All these devices have one common property i.e., they respond to any microbial infection without pausing to determine the invader's identity. The cells and chemicals of second line of defence, defend the body to attack and kill the invaders.

The second line of defence consists of three types of mechanisms i.e., natural

killer cells, inflammatory responses and temperature responses.

### 13.2.1 Killing cells of blood

Perhaps the most important of vertebrate body's non-specific defence are the white blood cells called leucocytes. These cells circulate through the body and attack invading microbes within tissue. There are three basic kinds of these cells and each kill invading micro-organism differently.

#### Macrophages:

The macrophages (Big eaters) are large irregularly shaped cells that kill microbes by ingesting them through phagocytosis (like *Amoeba*).

They are found in organs such as lungs, liver, spleen, kidney and lymph nodes rather than remaining in the blood.

They leave the bone marrow and travel into the blood as monocytes, where they develop into macrophages. Once they leave the blood and settle in the organs, they remove any foreign matter found there.

The macrophages are long-lived cells. They play a crucial role in initiating immune response. They do not destroy pathogens completely but cut them up to display antigens that can be recognized by lymphocytes. Macrophages secrete some types of proteins which trigger maturation of monocytes. A protein interleukin-1 stimulate the hypothalamus to raise body temperature, and other protein stimulate the specific response.

#### Neutrophils:

The neutrophils are types of white blood cells that, like macrophages destroy the pathogens by phagocytosis. In addition neutrophils release lysozyme, chemicals that kill other bacteria in the neighbourhood. Neutrophils have short life span, after killing and digesting some pathogens they die. Dead neutrophils are collected at the site of infection to form pus. Due to pseudopodial movement, their body squeeze and can enter all those parts of tissues where other WBC can not enter. These are most abundant types of WBCs in most mammals, about 40 to 70%.

#### Do you know?

How neutrophil is different from lymphocytes, second line of defence and third line of defence.

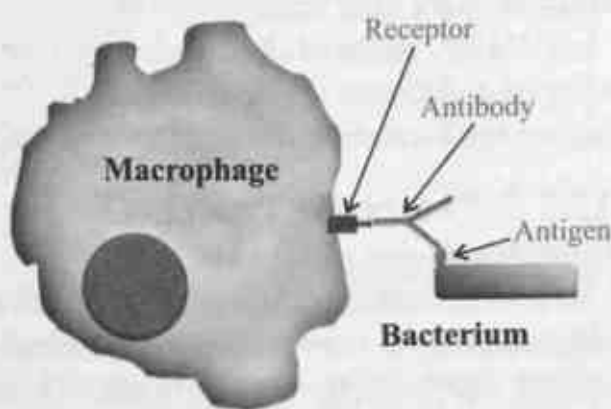


Fig. 13.3 Macrophage

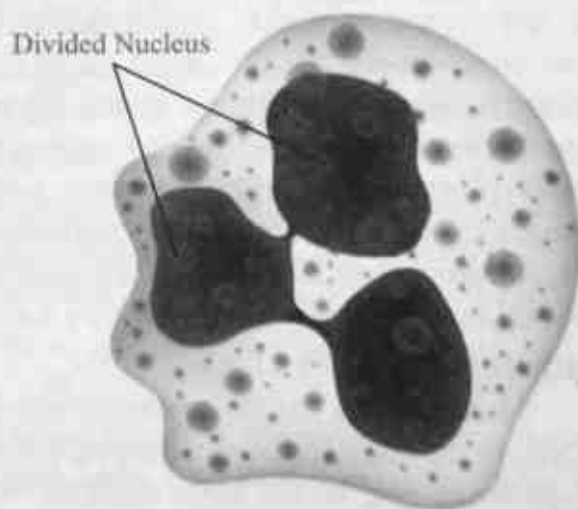


Fig. 13.4 Neutrophils

### Natural killer cells:

These cells do not attach invading microbes directly instead they kill cells of the body that have been infected. They do not phagocytose microbes but rather by creating a hole in the plasma membrane of target cell. Proteins called **perforins** are released from the membrane of the natural killer cells and inserted into membrane of target cell which then swell and bursts, by a protease (enzyme).

The natural killer cells cause very effective defence against cancer cells usually before the formation of malignant tumor.

### 13.2.2 Protective Proteins (complement system)

The cellular defence of vertebrates are enhanced by a very effective chemical defence called the complement system. This system consists of approximately 20 to 30 different proteins formed in the liver, that circulate freely in the blood plasma. When these proteins encounter bacterial or fungal cells then these proteins form a membrane attack complex that inserts itself into the foreign cells (pathogen cells) plasma membrane forming a pore like natural killer cells. The water enters the foreign cell (pathogen cells) through this pore causing, the cell to swell and burst.

### Interferons (IFNs):

These belong to cytokines (Protein in lymph cells). Interferons is another class of proteins that plays a key role in the body defence. There are three major categories of interferons. These are grouped into two types. Type I, alpha and beta while type II is gamma. These cells of the body synthesize alpha and beta interferons. These polypeptides act as messengers, that protect normal cells in the vicinity of infected cells from becoming infected. Though viruses are still able to penetrate the neighbouring cells. The **alpha and beta interferons** prevent viral replication and protein assembly in these cells. (Thus named interferons means interfere with viral replication inside body cell).

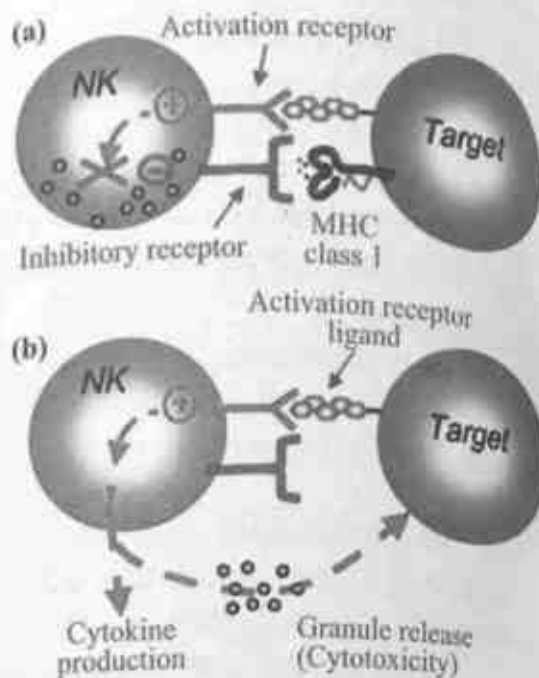


Fig. 13.5 Natural Killer Cell (NK)

### Activity

Justify why the physicians prescribe antipyretic drugs, when fever is a nonspecific defence against microbial infection.

### Tit bits

Aspirin reduce the degree of fever because aspirin impedes the formation of prostaglandin from arachidonic acid. Drugs like aspirin that reduce fever are called antipyretic.

### Activity

How antihistamine therapy is helpful to the patients of runny nose and skin rashes?

**Gamma interferon** is produced only by particular lymphocytes and natural killer cells. Gamma interferons defend against infection and cancer. These also activate other immune cells such as macrophages and natural killer cells.

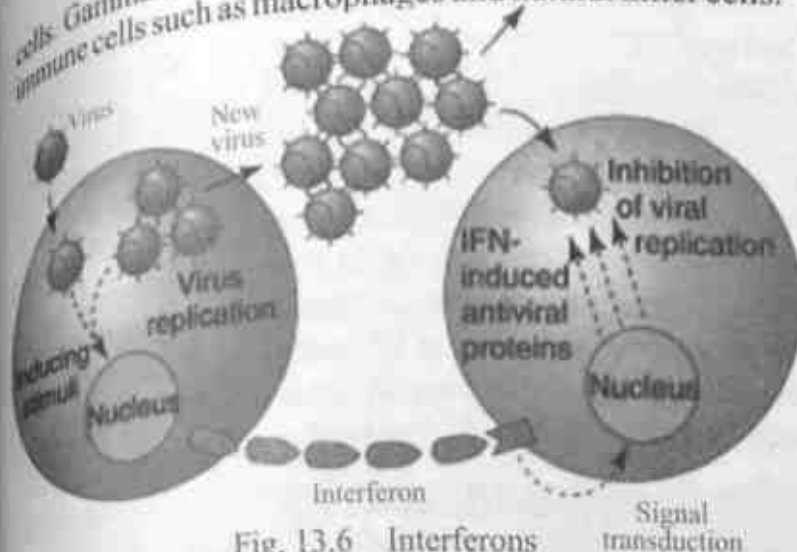


Fig. 13.6 Interferons

### Tit bits

Invading bacteria and viruses are recognized as foreign because they contain molecules, which are different from any of our own molecule. These foreign molecules are known as **antigens**.

### Inflammatory Responses:(means setting on fire)

The inflammatory response is a localized, nonspecific against infection. Infected or injured cells release chemical alarm signals, most notably **histamine** and **prostaglandins** (Produced from all nucleated cells). These chemicals promote the dilation of local blood vessels, which

### Tit bits

**Histamine** secreted from basophils and mast cells which are a class of WBC. These cells are filled basophil granules found in number of tissues.

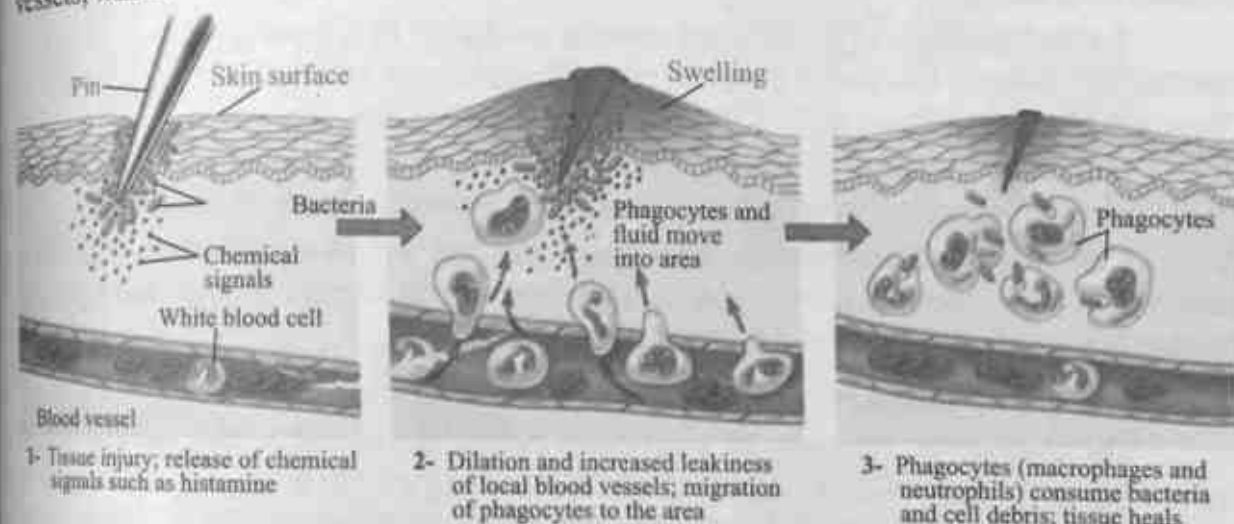


Fig. 13.7 Inflammatory Responses

increase the flow of blood at the site of infection or injury and causes the area to become warm, red, swollen and feel pain. They also increase the permeability of capillaries in the area producing **edema**. Phagocytes migrate from the

### Activity

Search net to see the difference between two sub classes of monocytes.

blood to the extra cellular fluid where they can attack bacteria. The function of inflammation is to remove necrotic cells and to start repair process and prevent spreading of infection.

### 13.2.4 Temperature Responses

Macrophages that encounter invading microbes release a regulatory molecule called interleukin-1 which is carried by blood to the brain. **Interleukin-1** and other **pyrogens** (Greek Pyr=fire) such as bacterial endotoxins cause neurons in the hypothalamus to raise the body temperature several degrees above the normal value of  $37^{\circ}\text{C}$  ( $98.6^{\circ}\text{F}$ ). The elevated temperature thus results is called fever. Fever contributes to the body's defence by stimulating phagocytosis and causing the liver and spleen to store iron, reducing blood level of iron which bacteria need in large amount to grow. However very high fever is harmful because excessive heat may denature critical enzymes and proteins of body. Therefore, the patient is given antipyretic drugs.

### 13.3 Third Line of Defence: (The specific defence)

Many of us contract some sort of infection in our childhood, small pox for example, is an illness that many of us experience before we reach our teens. It is a disease of childhood as most of us contract it in childhood stage and never catch it again. Once you have had the disease, you are usually immune to it. The specific immune defence mechanism provides such immunity.

**An antigen** is a molecule capable of inducing an immune response in the host. These are usually foreign bodies but sometimes these are part of host itself in an autoimmune disease.

**An antibody** is a "Y" shaped protein produced by plasma cells to destroy or neutralize antigens. These are attached on pathogens and secreted by B. lymphocytes. The third line of defence is specific and most effective consists of two types.

1. **Humoral immunity**, mediated by macromolecules found in the extra cellular fluids such as antibodies, complement proteins and certain antimicrobial peptides.
2. **Cell mediated immunity**: This type does not involve antibodies; but rather involve the activation of phagocytes, antigen specific cytotoxic T- Lymphocytes and release of various cytokines in response to antigens.

#### 13.3.1 Role of Monocytes in Third Line of Defence

The monocytes are types of leukocytes (white blood cells), they are the largest type of leukocytes. As part of vertebrate innate immune system (discussed in second line of defence), monocytes also influence the process of adaptive immunity. There are at least two sub classes of monocytes in human blood.

i) **Dendritic cells**:- These are antigen presenting cells, mark out foreign bodies to be destroyed by lymphocytes.

ii) **Macrophage**:- These are large phagocytic cells.

### 13.3.2 Role of T-Cells in Third Line of Defence: (cell mediated immunity)

T-Cells or T. Lymphocytes are a type of lymphocytes (a type of WBC) that play a central role in cell mediated immunity. T-cell can be distinguished from other lymphocytes such as B-Cells and natural killer cells by the presence of a T-Cell receptor on the cell surface. They are called T-Cells because they mature in the **thymus** from thymocytes, an endocrine gland in chest (some are synthesized in tonsils also).

**Activation of T-Cells:** When infection occurs the T-cells detect particular antigen of invading micro-organism by engulfing it. The T-Cells display these antigen on their surface with the help of their own protein known as **Major Histocompatibility Complex (MHC)**. In this way, macrophages become **antigen presenting cells (APCs)**. At the same time macrophages release **interleukin 1** that stimulates helper T-Cells and attracts them towards displayed antigen. The helper T-Cells have receptor by which they bind with specific antigen present on APC. The receptor on surface of T-Cells are called T-cell receptor (TCR). The T-cell also stimulated by interleukin to secrete another protein called **interleukin 2** which

#### Tit bits

*The primary response is slow because at this stage there are very few B-cells that are specific to antigen.*

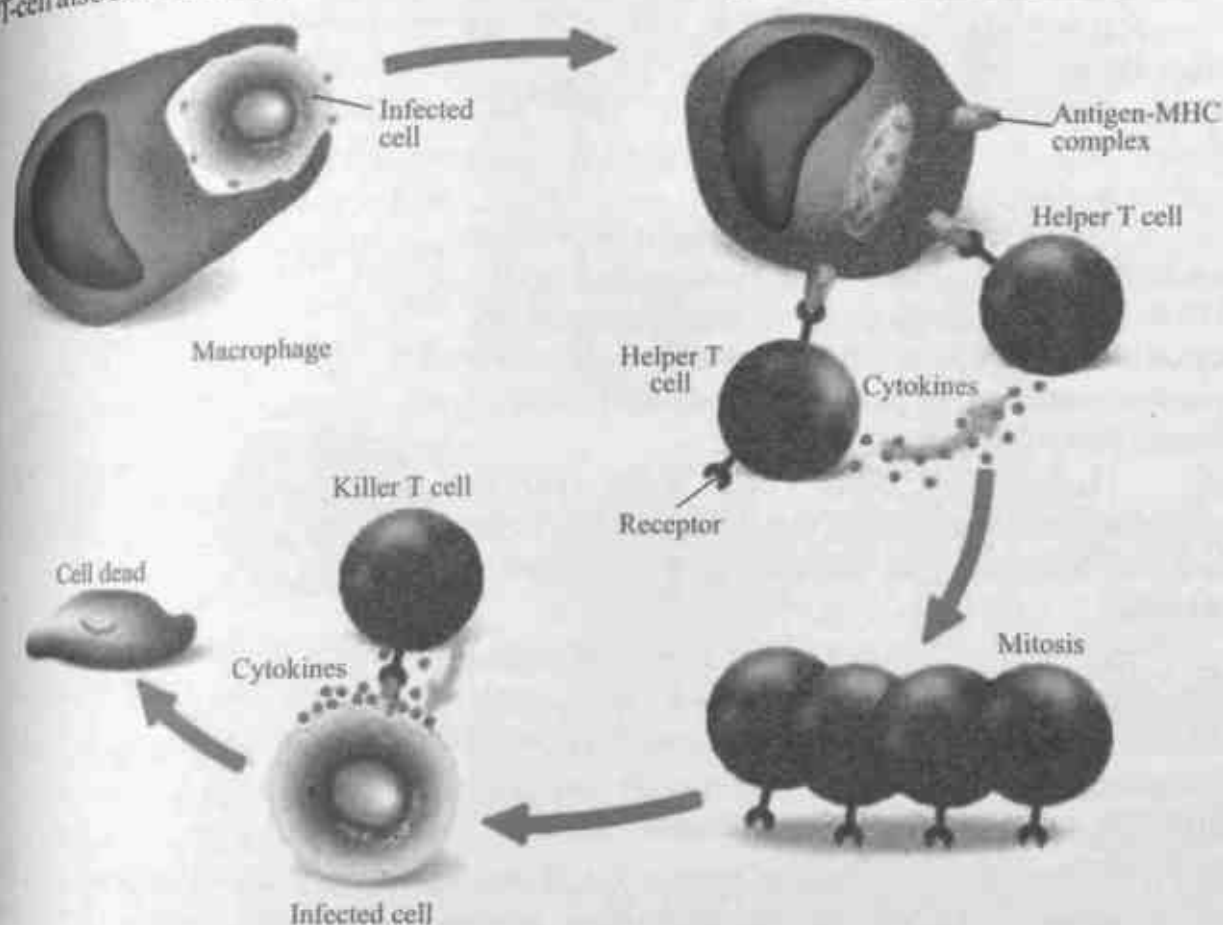


Fig. 13.8 Cell Mediated Immune Response

is not only responsible for division of helper cells but also proliferates certain cytotoxic T-cells and B cells. There are millions of different T-cells, as each type of T-cells respond to a specific type of antigen. This type of immunity is called cell mediated immunity.

**Types of T-Cells:** The T-lymphocytes are of two types i.e., **CD8** (cluster of differentiation) as they have surface marker CD8, include cytotoxic T-cells and suppressor T-Cells. The other group is helper T-Cells also called **CD4** cells due to presence of surface marker CD4. On activation, the T-Cells divide and produce 4 types of cells, these four types of cell play vital role in cell mediated immune response. The four types of cells produced by T-cells are as follow.

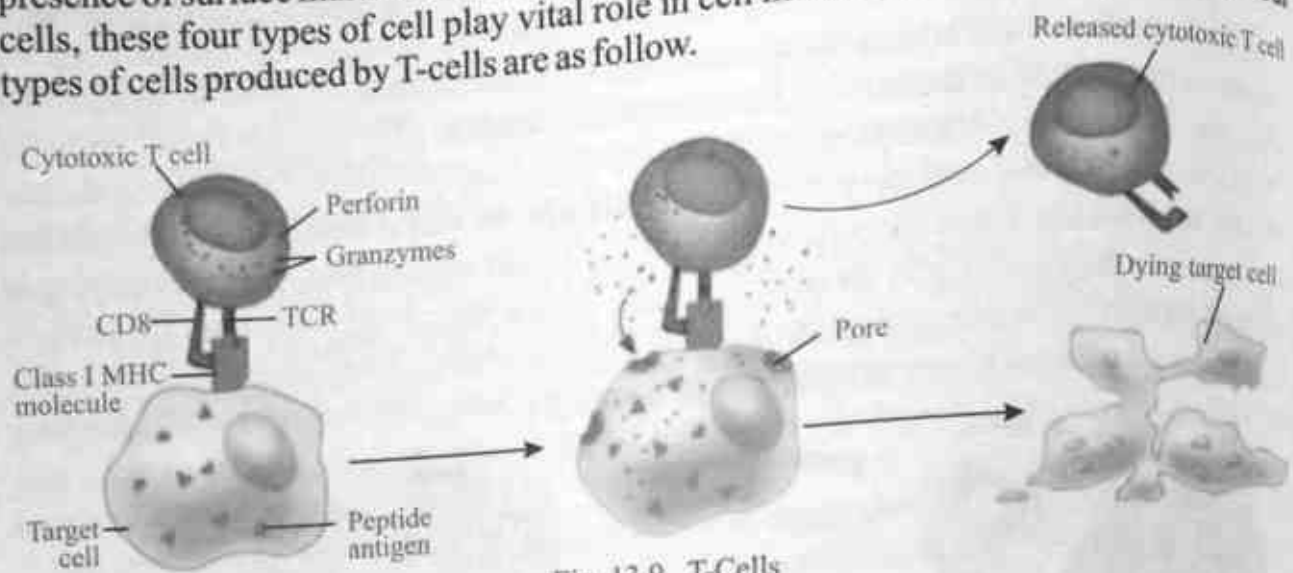


Fig. 13.9 T-Cells

a. **Cytotoxic T-Cells:** These cells produce a toxin called **cytotoxin**. This destroy pathogen's DNA and perforin protein is also produced by cytotoxic T-cells. The perforin creates hole in the plasma membrane of pathogen as a result pathogen breaks down into pieces.

b. **Helper T-Cells:** These cells secrete cytokines which stimulate the division of B-Cells and T-Cells to increase defense against pathogenic attacks.

c. **Suppressor T-cells:** After the successful removal of infection the suppressor T-Cells secrete certain proteins that inhibit further proliferation of T-Cells, Thus immune response is blocked therefore, the cells are called suppressor T-Cells.

d. **Memory T-Cells:** This type of T-cells remain inactive for many years after the initial exposure to antigen. However they become active very quickly during the secondary response to antigen and fight against pathogen.

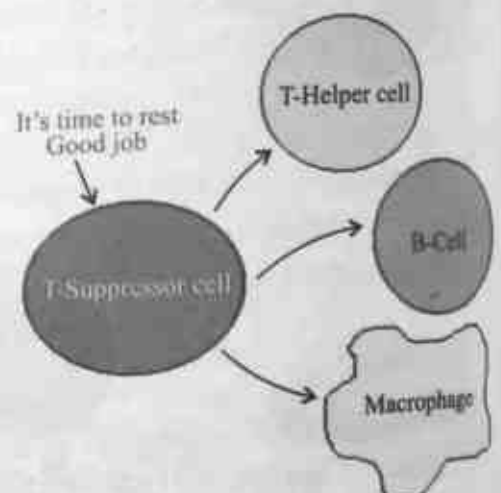


Fig. 13.10 Binary Fission

### 13.3.3 Role of B-Cells in Third Line of Defence "Humoral immunity" or Antibody Mediated immune response.

The antibodies are small glycoprotein molecules.

B-lymphocytes secrete antibodies, which destroy bacterial pathogens. B-lymphocytes are so called because they develop in the bone marrow and first discovered in the bursa of intestines of birds.

As mentioned earlier in this chapter that antigens are foreign molecules because they are different from any of our own molecules. We have a huge number of B-lymphocytes in our blood each one of them recognizes and responds to one particular antigen. The B-lymphocytes respond by producing antibodies.

#### Activation of B-Lymphocytes

Most B lymphocytes will spend all their lives without anything happening to them at all because they never meet their particular antigen. But a B-lymphocyte does encounter an antigen which binds to the receptors on its cell surface membrane, it is triggered into action. After encountering its

specific antigen, the B-lymphocyte is stimulated to divide repeatedly by mitosis. Some of these cells differentiate into **plasma cells**. These cells have the ability to produce very large number of antibody molecule in very less time (2000 antibody molecules per second). These antibodies bind with antigens and destroy them.

Other cells produced as a result of mitosis do not secrete antibody, instead they remain as **memory cells**. These cells live for long time and remain circulating in the blood, they are capable of responding very quickly if the same type of antigen enters the body again.

1- Ingestion of antigen (pathogen) by macrophage



Antigens presented



2- Activation of B cell and helper T cell



3- Formation of a clone



Secrete antibodies



Remember the antigen for future encounters

Fig. 13.11 Antibody mediated response

## Structure of Antibody:

Antibodies are all globular glycoproteins and form the group of plasma proteins called **immunoglobulins**.

The basic molecule common to all antibodies consisting of four polypeptides chains two **long (heavy) chains** and two **short (light) chains**. **Disulphide bridge**, hold the chains together. Each molecule has two identical antigen binding sites which are formed by both heavy and light chains. The sequence of amino acids in these regions make the specific three dimensional shape which binds to just one type of antigen. This is the variable region which is different on each type of antibody molecule produced. The hinge region gives the flexibility for the antibody molecule to bind around the antigen.

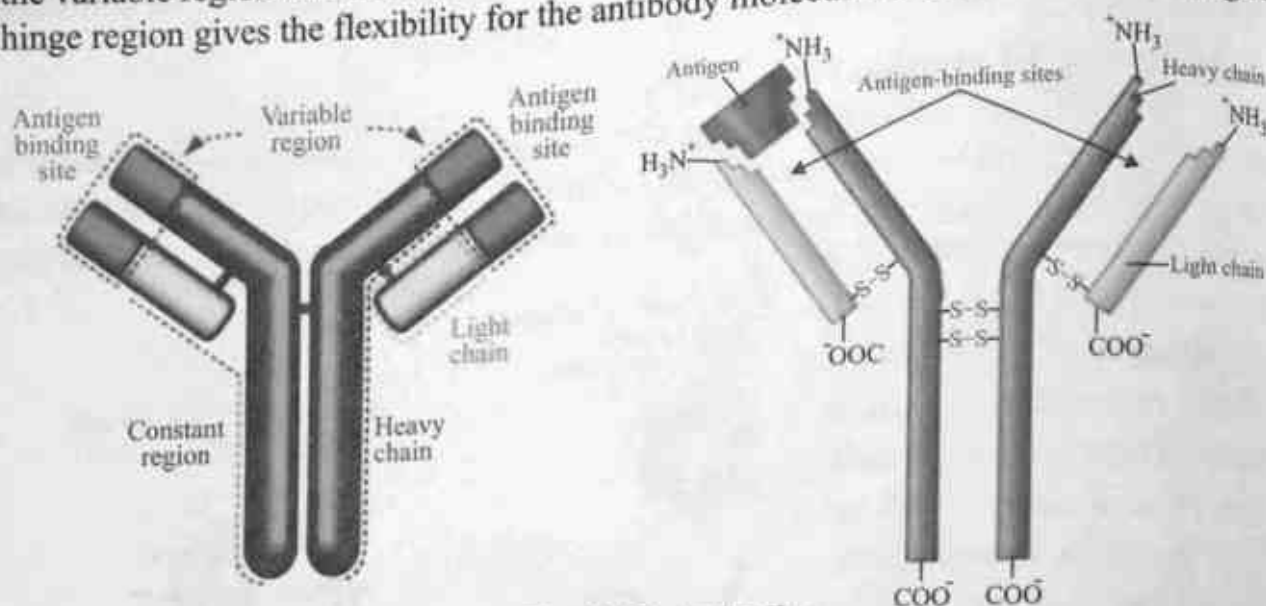


Fig. 13.12 Antibodies

**Mode of action of antibody:** There are different modes of action of antibodies, some important modes are given below.

**Neutralizing antibody:** In this type of mode of action of antibody, an antibody that defend a cell from an antigen or infection by neutralizing any effect it has biologically. An example of a neutralizing antibody in diphtheria antitoxin.

### Activation Complement:

The complement proteins are group of plasma protein, which are made by liver. These proteins are activated by an antigen antibody complex. These proteins usually cluster together to form a pore or channel that insert into a microbe plasma membrane to lyse the cell. Some of these complement proteins can cause chemotaxis and inflammation. Due to these activities number of white blood cells increase at the site of infection.

### Do you know?

There are 5 classes of antibodies i.e. immunoglobulin IgG, IgM, IgD, IgA and IgE.

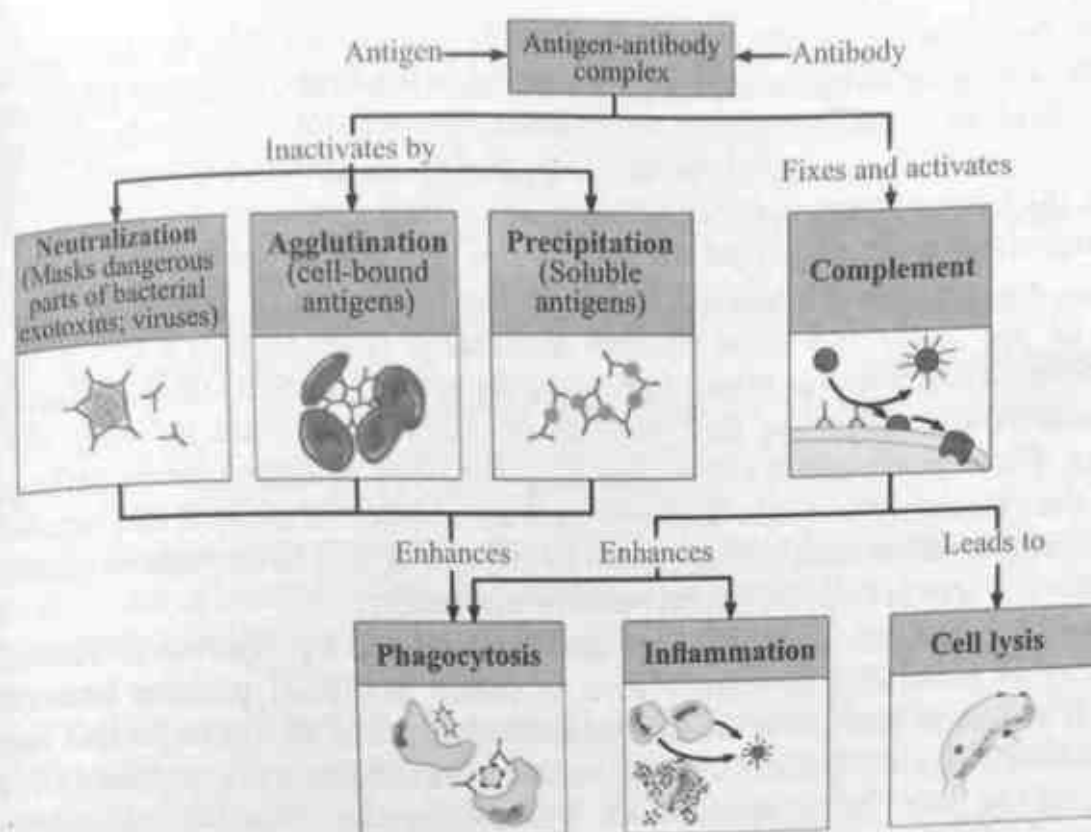


Fig. 13.13 Mode of action of antibody

**Precipitating antigens:** When antibodies bind to some free antigen, cause the antigen to precipitate out of solution, thus phagocytic cells can easily ingest them.

**Facilitating phagocytosis:** When antigen antibody complex is formed it signals the phagocytic cells to attack. This complex binds to the surface of macrophages, it facilitates phagocytosis.

### 13.3.4 Inborn and Acquired Immunity

As discussed in the early part of this chapter that inborn (innate) immunity is non specific and makes the first and second line of defence. On the other hand the acquired (adaptive) immunity is highly specific and develops in reaction of antigens. However, it takes several days to become fully functional.

**Types of acquired or Induced immunity:** Acquired immunity may be active or passive and either type may be acquired naturally or artificially.

**Active immunity:** It is a kind of immunity which develops after contracting pathogen inside the body. The body has been stimulated to make a particular type of antibody and can produce these same ones more quickly in large quantity, if it is exposed to same pathogen again. The immunity has developed naturally, is called as **natural active**

#### Activity

Do you know what are auto grafts?

#### Tit bits

Organ transplant is a medical procedure in which an organ is removed from donor body and placed in the body of recipient to replace a damaged or missing organ.

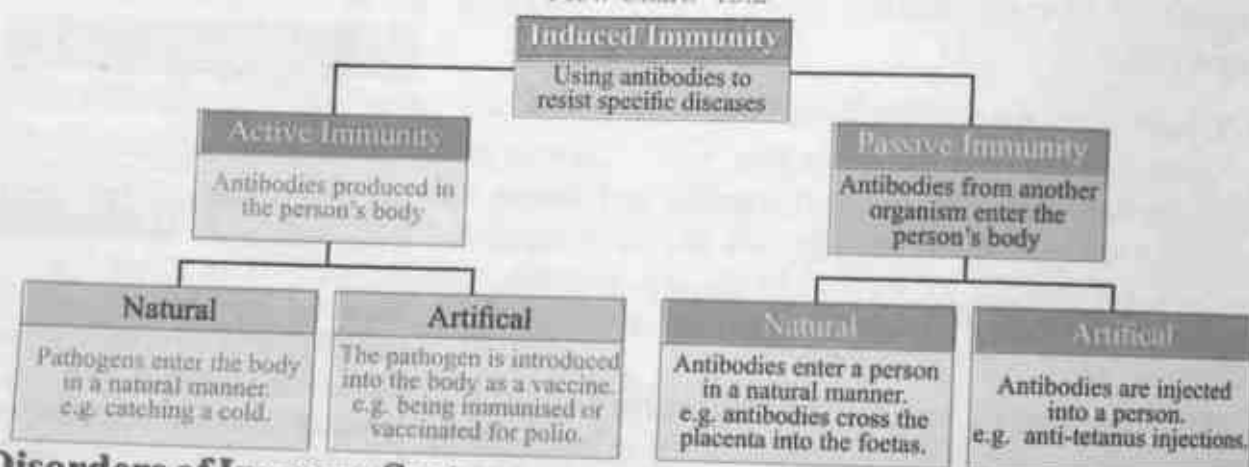
Another way in which active immunity can develop is by vaccination. This involves injecting the antigen into body. It may be in the form of viruses which have been made harmless, or as an inactivated toxin from a bacterium. The body responds in the same way as it would, if invaded by the living pathogen, producing memory cells which will make the person immune to the disease that is they may ever encounter it. This way of acquiring active immunity is not natural. So it is called **artificial active immunity**.

**Passive immunity:** It is observed that a young baby's immune system takes time to develop. In the uterus the fetus obtains antibodies from mother's blood, across the placenta. After birth, it will continue to receive them from mother's milk. **Colostrum**, thin yellow milk produced in the first few days after birth. This is especially rich in antibodies. These ready made antibodies help the baby to fight against pathogens. The baby has the immunity to same diseases as their mother because it has received ready made antibodies, rather than making them itself, this is said to be passive immunity as it occurs naturally so it is called **natural passive immunity**.

However passive immunity can also be provided by injections. This is not the natural way of providing immunity so it is called **artificial passive immunity**. For example if a person has cut or wound on its body, he/she needs to protect against the bacterium that cause tetanus. Tetanus is caused by the infection of bacterium *Clostridium tetani*. It is too late for a vaccination, because by the time their immune system responded, the bacterium would have multiplied and cause **fatal illness called tetanus**. Instead the person will be given an injection of antitoxin. The antitoxin will bind to the toxin produced by bacteria, rendering it harmless.

Passive immunity does not last as long as active immunity. No lymphocytes have been stimulated to produce clone of themselves, so no memory cells have been formed.

Flow Chart: 13.2



## Disorders of Immune System

An autoimmune disorder is a condition arising from abnormal immune response to a normal body part. There are at least 80 types of autoimmune diseases. Nearly all body parts can be involved. Common symptoms include low grade fever, feeling tired, often symptoms appear and disappear. Some examples of autoimmune disorder are:

**Allergies:** Allergic diseases are number of disease conditions caused by

hypersensitivity of the immune system to some thing (Allergens) in the environment that usually causes little or no problem in most people. These diseases **cause** hay fever, food allergies, atopic dermatitis, allergic asthma etc. **Symptoms** may include red eyes, an itchy rash, sneezing, runny nose, shortness of breath or swelling.

The cause of allergies are usually genetic and environmental factors like pollen, metals, food, insect stings, drugs etc.

Usually antihistamine is given to allergic patients because in allergic conditions histamine production increases.

**Transplant rejections:** Transplant rejections occur when transplanted tissue is rejected by the recipient's immune system, which destroy the transplant tissue. This happens when recipients cells may recognize the donor's organ's or tissue as being foreign. As a result the recipient immune system activates against transplant organ and destroys it.

### Role of T-Cells and B-Cells in transplant rejection

Rejection is an adaptive immune response via cellular immunity mediated by killer T-Cells. It induces apoptosis of T-Cells as well as humoral immunity mediated by activated B-Cells secreting antibody molecules. Although the action is joined with the components of innate immune response i.e., phagocytosis and soluble immune proteins. However different types of transplant tissues tend to favor different balances of rejection mechanisms.

### Do you know?

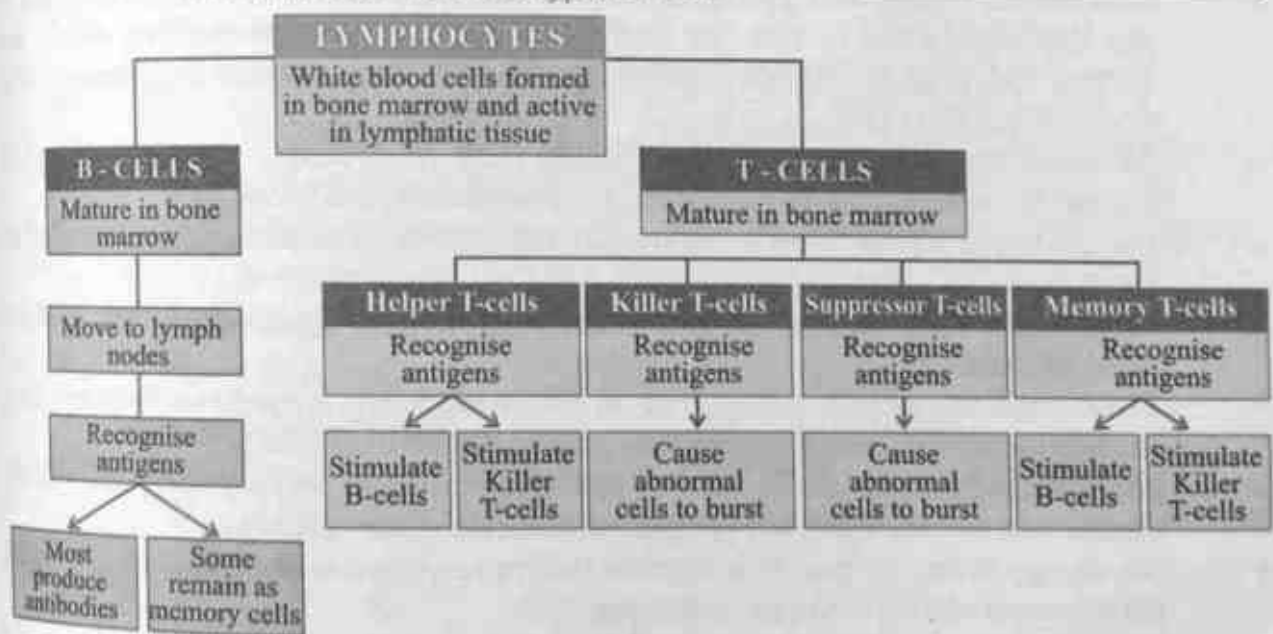


*Stress can affect the way our immune system works. It can lead to increased level of cortisol which can blunt immune system. While positive emotions and a healthy life style may boost our immunity. Sleep deprivation can also impact.*

### Activity

*Being too clean, can inhibit your immune system from functioning properly. Justify this statement by searching the information from different sources.*

Flow chart 13.3 Different types of WBC



## SUMMARY

- Defense system that had evolved to protect animals from invading pathogenic microorganisms and cancer is called as immune system and its study is called as immunology.
- The outermost layer of the vertebrate body, the skin, is the first barrier or first line of defense to penetration by microbes. Mucous membrane in the respiratory and digestive tracts is also important barriers that protect the body from invasion.
- The skin is the largest organ of the vertebrates and human body, accounting for 15% of an adult human's total body weight.
- The dermis of skin is 15 to 40 times thicker than the epidermis. It provides the structural support for the epidermis and the matrix for the many blood vessels, nerve endings, muscles, and other structures situated within skin.
- The body uses a host of nonspecific cellular and chemical devices to defend itself. We refer to this as second line of defense.
- The lymphatic system consists of network of lymphatic capillaries, ducts, nodes and lymphatic organs, and although it has other functions involved with circulation, it also stores cells and other agents used in the immune response.
- Macrophages are large eating cells, irregularly shaped cells that kill microbes by ingesting them through phagocytosis.
- Natural killer cells also known as "NK" do not attack invading microbes directly. Instead, they kill cells of the body that have been infected with viruses.
- The cellular defenses of vertebrates are enhanced by a very effective chemical defense called the complement system. This system consists of different proteins that circulate freely in the blood plasma.
- The inflammatory response is a localized, nonspecific response to infection.
- Interleukin-1 and other pyrogens such as bacterial endotoxins cause neurons in the hypothalamus to rise the body's temperature several degrees above the normal value of 37 degree centigrade (98.6F). The elevated temperature that result is called fever.
- Antigens are large, complex molecules such as proteins; they are generally foreign to the body, usually present on the surface of pathogens.
- Lymphocytes called B-cells respond to antigens by producing proteins called as antibodies.
- The immune defense mechanisms of the body involve the actions of white blood cells, or leukocytes.
- The recognition of infectious agents in innate immunity is mediated by germ line-encoded receptors called pattern recognition receptors (PRRs).
- Each antibody molecule consists of two identical short polypeptides, called light chains, and two identical long polypeptides, called heavy chains.
- An allergy is an excessive or hypersensitive response of the immune system to harmless substance in the environment.

## EXERCISE

### Section I: Objective Question

#### Multiple choice Questions

A. Choose the correct answer.

1. Which of the following can not induce immunity?  
(a) Bacteria (b) Parasites  
(c) Virus (d) Worms
2. Skin is a \_\_\_\_\_ barrier.  
(a) Anatomical (b) Phagocytic  
(c) Physical (d) Inflammatory
3. Which among the following is anti-bacterial?  
(a) Interferon (b) hormone  
(c) Amylose (d) Protein
4. Which of the following is anti-viral?  
(a) Lysozyme (b) protein  
(c) Interferon (d) Hormone
5. Identify the phagocytic cells from the following combination.  
(a) Macrophage and Neutrophil (b) Macrophage and eosinophil  
(c) Lymphocyte and eosinophil (d) Eosinophil and neutrophil
6. Histamine is secreted by.  
(a) Epithelial cell (b) Red blood cells  
(c) Mast cells (d) White blood cells
7. Humoral immunity consists of:  
(a) Normal cells (b) Cytotoxic cells  
(c) Pathological cells (d) Immunoglobulin molecules
8. Which of the following secretes immunoglobulin.  
(a) T-lymphocyte (b) Macrophage  
(c) B-lymphocyte (d) Mast cells
9. Immunoglobulin are chemically.  
(a) Glycogens (b) Glycolipids  
(c) Glycoproteins (d) Lipoproteins
10. Colostrum is especially rich in.  
(a) Antibodies (b) Antigen  
(c) Sucrose (d) Histamine

**B. Fill in the Blanks.**

1. MHC is the abbreviation of \_\_\_\_\_.
2. The study of immunity is called \_\_\_\_\_.
3. Sweat from sweat glands gives the skin surface pH of \_\_\_\_\_.
4. Dead neutrophils after collected at the site of infection to form \_\_\_\_\_.
5. \_\_\_\_\_ is thin yellow milk produce in the first few days after child birth.
6. All antibodies are made of polypeptide \_\_\_\_\_.
7. Cytotoxic T-cells produces a type of toxin known as \_\_\_\_\_.
8. Tetanus is caused by a bacterium named \_\_\_\_\_.
9. The active immunity developed naturally is called \_\_\_\_\_.

**Section II: Short Questions**

1. How do macrophages destroy foreign cells?
2. How does complement system participate in defence against infection?
3. In what two ways do macrophages activate helper T cells? How do helper T cells stimulate the proliferation of cytotoxic T cells?
4. What are memory cells?
5. Define the terms T-cell, B-cell, antigens, antibodies, microbes, monocytes and vaccines.
6. Differentiate between antibody and cell mediated immune response.
7. Write the benefits of fever.
8. What are the major differences between innate and adaptive responses?
9. Write a note allergic diseases.
10. How and why might transplant be rejected?

**Section III: Extensive Question**

1. Explain second line of defence and discuss its types.
2. Write note on complement system.
3. Describe third line of defence.
4. What are different types of T-cells? Discuss.
5. Differentiate between active and passive immunity.
6. Write in detail diseases of immune system.
7. What is the role of B-cell in third line of defence?
8. Describe the structure of antibodies.
9. Describe protective proteins.
10. Explain on inflammatory and temperature responses.

## Greek and Latin Roots in Biology

auto = self, e.g. autotroph [Greek]

bios = life, e.g. biology, biomass [Greek]

bis = twice, e.g. binary fission, bicuspid valve [Latin]

chloros = (pale) green, e.g. chlorophyll, [Greek]

chroma = colour, e.g. chromatopsia, chromosome [Greek]

dia = across, e.g. diaphragm, dialysis [Greek]

di = twice, e.g. dichromatic, diploid, dipeptide [Greek]

ektos = outside, e.g. ectoparasite [Greek]

epi = upon (above), e.g. epicotyl, epidermis [Greek]

exo = outside, e.g. exocytosis, exoskeleton [Greek]

haima = blood, e.g. haemoglobin, haemophilia [Greek]

heteros = other (different), e.g. heterozygous [Greek]

homos = same, e.g. homologous, homozygous [Greek]

hypo = under, e.g. hypocotyl, hypothermia [Greek]

inter = between, e.g. inter-cellular, intercosta [Latin]

intra = within, e.g. intra-cellular, intra-uterine [Latin]

kytos = vessel (a cell), e.g. cytoplasm, erythrocyte, leucocyte [Greek]

lipos = fat, e.g. lipase, lipid [Greek]

lysis = dissolution, e.g. dialysis, lysozyme [Greek]

mesos = middle, e.g. mesenteric, mesophyll [Greek]

meta = after (change), e.g. metamorphosis

[Greek]

mikros = little, e.g. micropyle, microvilli [Greek]

morphe = form (shape), e.g. metamorphosis, morphology [Greek]

phagein = to eat, e.g. oesophagus, phagocyte [Greek]

phyllon = leaf, e.g. chlorophyll, mesophyll [Greek]

phyton = plant, e.g. phytoplankton, saprophyte [Greek]

polys = many, e.g. polypeptide, polysaccharide [Greek]

protos = first formed, e.g. protista, protoplasm [Greek]

rhiza = root, e.g. rhizoid, rhizome [Greek]

semi = half, e.g. semicircular canal, semilunar valves [Latin]

sub = under, e.g. sub-cutaneous, subclavian, subsoil [Latin]

sym-, syn = together, e.g. symbiosis, synapse [Greek]

tres = three, e.g. triceps brachii, tricuspid valve, tripeptide [Greek]

trophe = food, e.g. autotroph, trophic level [Greek]

unus = one, e.g. unicellular, unisexual [Latin]

vas = vessel, e.g. vascular bundle, vasodilation, vasodilator [Latin]

zoon = animal, e.g. zoology, zooplankton [Greek]

## Glossary

### A

**Abscisic acid:** Plant hormone that promotes stomatal closure, bud dormancy, and seed dormancy.

**Abscission:** The dropping of leaves, flowers, fruits, or other plant part due to hormonal action.

**Absorption:** In most animals, movement of nutrients, fluid, and ions across the gut lining and into the internal environment.

**Accessory Pigment:** Light-trapping pigment molecule; it contributes to photosynthesis by extending the range of usable wavelengths beyond those absorbed by the chlorophylls.

**Acid:** A substance that releases hydrogen ions when dissolved in water.

**Acoelomate:** of some of the invertebrates, having no fluid-filled cavity between the gut and body wall.

**Activation energy:** The minimum amount of collision energy necessary to drive reactant molecules to an activated state at which a given chemical reaction will proceed spontaneously.

**Active site:** A cleft in the surface of an enzyme molecule where a specific reaction is catalyzed, or made to proceed far faster than it would spontaneously.

**Active transport:** The solute is transported against its concentration gradient. An energy boost, as from ATP, activates the protein.

**Adenine:** A purine; a nitrogen-containing base in certain nucleotides.

**Adipose tissue:** A type of connective tissue having an abundance of fat-storing cells.

**Aerobic respiration:** The main pathway of ATP formation, for which oxygen is the final acceptor of electrons stripped from glucose or another organic compound.

**AIDS:** Short for acquired immunodeficiency syndrome.

**Alcohol:** An organic compound that has one or more hydroxyl groups (-OH) and readily dissolves in water. Sugars are examples.

**Alcoholic fermentation:** Anaerobic pathway of ATP formation. Pyruvate from glycolysis is degraded to acetaldehyde, which accepts electrons from NADH to form ethanol with a net yield of two ATP. NAD<sup>+</sup> is regenerated.

**Amino acid:** A small organic molecule with a hydrogen atom, an amino group, an acid group, and an R group bonded covalently to a central carbon atom; the subunit of polypeptide chains or protein.

**Amphibians:** A type of vertebrate somewhere between fishes and reptiles in body plan and reproductive mode, example salamanders, frogs and toads.

**Anaerobic pathway:** Metabolic pathway in which a substance other than oxygen serves as a final acceptor of electrons that have been stripped from substrates.

**Angiosperm:** A flowering plant.

**Annual:** A flowering plant that complete its life cycle in one growing season.

**Anther:** A pollen-bearing part of a stamen.

**Antibiotic:** One of many metabolic products of certain microorganisms that can kill their bacterial competitors for nutrients in soil.

**Antibody:** One of diverse array of antigen-binding receptors. Only B- WBC makes antibody molecules and position them their surface or secrete them.

- Antigen:** A molecular configuration that white blood cells recognize as foreign and that triggers an immune response. Most antigens are protein at the surface of pathogens or tumor cells.
- Aorta:** Main artery of systemic circulation; carries oxygenated blood away from the heart to all body regions except the lungs.
- Apical dominance:** Inhibitory influence of a terminal bud on growth of lateral buds.
- Apical Meristem:** A mass of self-perpetuating cells responsible of primary growth at root and shoot tips.
- Apoptosis:** Of multicelled organisms, a program natural death of cell.
- Archaeobacteria:** A kingdom of prokaryotes; methanogens, halophiles, and thermophiles.
- Artery:** A large-diameter, rapid-transport blood vessel with a thick, muscular wall, carrying away from heart.
- Asexual Reproduction:** Any of number of modes of reproduction by which offspring arise from a single parent and inherit the genes of that parent only.
- Atmosphere:** A volume of gases, airborne particles, and water vapor that envelops the earth.
- Atom:** A smaller particle unique to a given element; it has one or more positively charge protons, electrons, (except for hydrogen), neutrons.
- Atomic number:** The number of proton in a nucleus of each atom of an element; the number differ for each element.
- ATP:** Adenosine triphosphate. A nucleotide of adenine, ribose, and three phosphate groups that acts as an energy carrier.
- Autoimmune response:** Misdirected immune response in which lymphocytes mount and attack against normal body cells.
- Autotroph:** Organism that synthesizes its own organic compounds using carbon dioxide (as the carbon source) and energy from the physical environment (such as sunlight energy).
- Auxin:** A plant hormones that influences, growth such as stem elongation.
- ## B
- B- Lymphocyte: (B- cell)** The only white blood cell that produces antibodies, then positions them at the cell surface or secretes them as weapons in immune responses.
- Bacterial conjugation:** Transfer of plasmid DNA from one bacterial cell to another.
- Bacteriophage:** Category of viruses that infect bacterial cells.
- Basal body:** A centriole which after giving rise from microtubules of a flagellum or cilium, remain attached to its base in the cytoplasm.
- Base:** Any substance that accepts hydrogen ions when dissolved in water.
- Basophil:** Fast-acting white blood cells that secretes histamine and any other substances to maintain an inflammatory response.
- Biennial:** A flowering plant that lives through two growing seasons.
- Bilateral symmetry:** Body plan in which the left and right halves of an animal are mirror-images of each other.
- Binary fission:** A mode of asexual reproduction; whole body into two parts of the same or different sizes.
- Biogeochemical cycle:** The movement of an element from the environment to organisms, then back to the environment.
- Biological species concept:** A species is one or more population of individuals that are interbreeding under natural conditions and producing fertile offspring and that are

reproductively isolated from other such populations. The concept applies only to sexually reproducing species.

**Biomass:** Combined weight of all organisms at a given trophic level in an ecosystem.

**Bipedalism:** Habitually walking on two feet, as by birds and human.

**Bird:** The only vertebrate that produces feathers.

**Blood:** A fluid connective tissue composed of water, solutes, and formed elements (blood cells and platelet) it carries substances to and from cells and helps to maintain internal environment favorable for cells activities.

**Blood pressure:** Fluid pressure, generated by heart contractions, that circulates blood.

**Bud:** An undeveloped shoot of meristematic tissue, primarily, often covered and protected by scales (modified leaves).

**Buffer system:** A partnership between a weak acid and base that forms when it dissolves in water. The two work as a pair to counter slight shifts in pH.

## C

**C4 pathway:** A pathway photosynthesis in which carbon dioxide is fixed twice, in two different cell types. Carbon dioxide accumulates in the leaf and helps counter photorespiration. The first compound formed is the 4-carbon oxaloacetate.

**CAM Plant:** A plant that conserves water by opening stomata only at night, when it fixes carbon dioxide by way of a C4 pathway.

**Cambium:** One of two types of meristems responsible for secondary growth (increases in stem and root diameter). Vascular cambium gives rise to secondary xylem and secondary phloem; cork cambium gives rise to periderm.

**Cancer:** A malignant tumor; weakens capacity for adhesion within the parent tissue (leading to metastasis) cancer is lethal.

**Carbohydrate:** A molecule that consists of carbon, hydrogen, and oxygen in a 1:2:1 ratio. All cells use carbohydrates as structural material, energy reservoirs, and transportable forms of energy.

**Carcinogen:** A substance or agent, such as ultraviolet radiation; that can trigger cancer.

**Cardiac cycle:** The sequence of muscle contraction and relaxation for one heartbeat.

**Cardiac pacemaker:** Sinoatrial (SA) node; the basis of normal rate of heartbeat. The self-excitatory cardiac muscle cells that spontaneously generate rhythmic waves of excitation over heart chambers.

**Cardiovascular system:** System of blood, one or more hearts, and blood vessels that functions in rapid transport of substances to and from cells.

**Carnivore:** An animal that eats other animals; a type of heterotroph.

**Carotenoid:** A light sensitive, accessory pigment that transfers absorbed energy to chlorophylls. Different types absorb violet and blue wavelengths and transmit red, orange and yellow.

**Carpal:** The female reproductive part of a flower; sometimes called a pistil.

**Cartilage:** A type of connective tissue with solid yet pliable intracellular material that resists compression.

**Casparian strip:** A waxy band that is an impermeable barrier between the walls of abutting cells making up the endodermis inside roots.

**cDNA:** Any DNA molecule copied from a mature mRNA transcript by way of reverse transcription.

**Cell:** The smallest living unit; an organized unit that can survive and reproduce on its own.

**Cell differentiation:** Developmental process in which different cell populations activate and suppress a fraction of their genes in different ways and so become specialized in composition, structure, and function.

**Cell plate:** A disc like structure that forms from remnants of a microtubular spindle when a plant cell divides; it develops into a cross wall that partitions the cytoplasm.

**Cell theory:** A theory in biology stating.

1. All organisms are composed of one or more cells,
2. The cell is the smallest unit that retains a capacity for independent life, and
3. All cells arise from preexisting cells.

**Cell wall:** A semi rigid, permeable structure that helps a cell hold its shape and resist rupturing if internal fluid pressure rises.

**Central vacuole:** A fluid-filled organelle in mature, living plant cells that stores amino acids, sugars, ions and toxic wastes. As it enlarges, it forces increases in cell surface area that improve nutrient uptake.

**Centriole:** A cylinder of triplet microtubules that gives rise to microtubules of cilia and flagella.

**Chemical bond:** A union between the electron structures of two or more atoms or ions.

**Chlorophyll:** A light-sensitive pigment that absorbs violet-to-blue and red wavelengths but that transmits green.

**Chloroplast:** An organelle that specializes in photosynthesis in plants and photosynthetic protists.

**Chordata:** An animal having a notochord, a dorsal hollow nerve cord, a pharynx, and gill slits in the pharynx wall for at least part of the life cycle. Mostly tail as fourth character.

**Chromosome:** Of eukaryotes, a DNA molecule with many associated proteins. Of prokaryotes, a DNA molecule without a comparable profusion of proteins.

**Cloaca:** Of some vertebrates, the last of a gut that receives feces, urine, and sperm or eggs; of some invertebrates, an excretory, respiratory, or reproductive duct.

**Coelom:** A cavity, lined with peritoneum, between the gut and body wall of most animals.

**Cohesion:** Capacity to resist rupturing when placed under tension (stretched).

**Collenchyma:** A simple plant tissue that offers flexible support for primary growth, as in lengthening stems.

**Commensalism:** A ecological interaction between species that directly benefits one but does not affect other much, if at all.

**Community:** All populations living in the same habitat. Also, a group of organisms with similar life-styles in a habitat, such as a community of birds.

**Companion cell:** A specialized parenchyma cell that helps load organic compounds into conducting cells of phloem.

**Complement system:** A set of about twenty proteins circulating in inactive form within vertebrate blood; different kinds induce lysis of pathogens, promote inflammation, and stimulate phagocytes to act during both nonspecific defenses and immune responses.

**Compound:** A substance consisting of two or more elements in unvarying proportions.

**Condensation reaction:** Through covalent bonding, two molecules combine to form a larger molecule, often with the formation of water as a by-product.

**Conifer:** A pollen and seed-bearing plant of dominant group of gymnosperms; mostly

evergreen, woody trees and shrubs with needle like or scale-like leaves.

**Cotyledon:** A seed leaf, which develops as part of the embryo of monocots and dicots; cotyledons provide nourishment for the seedling at the time of germination and initial growth.

**Covalent bond:** A sharing of one or more electrons between atoms or group of atoms.

**Cuticle:** A body covering. Of land plants, a transparent cover of waxes and lipid-rich cutin deposited on the outer surface of epidermal cell walls.

**Cyclic AMP:** A nucleotide; its functions in intercellular communications, as when it is a second messenger.

**Cytochrome:** Iron-containing protein molecule; a component of the electron transport systems used in photosynthesis and aerobic respiration.

**Cytoplasm:** All cellular parts, particles, and semi-fluid substances enclosed within the plasma membrane except for the nucleus (or nucleoids, in bacterial cells).

## D

**Denaturation:** Of any molecule, the loss of three-dimensional shape following disruption of hydrogen bonds and other weak bonds.

**Dermis:** The layer of skin underlying epidermis; consists of primarily of dense connective tissue.

**Diaphragm:** Muscular partition between the thoracic and abdominal cavities.

**Diffusion:** Net movement of like molecules (or ions) down their concentration gradient.

**DNA replications:** Of cells, the process by which hereditary material is duplicated for distribution to daughter nuclei. Occurs prior to mitosis and meiosis in eukaryotic cells and during prokaryotic fusion in bacterial cells.

**Double fertilization:** Of flowering plants only, the fusion of one sperm nucleus with the egg nucleus (to produce a zygote), and the fusion of a second sperm nucleus with nuclei of the endosperm mother cell, which gives rise to a nutritive tissue (endosperm).

## E

**Emulsification:** Of the chyme in the small intestine, a suspension of droplets of fat coated with bile salts.

**Endocrine gland:** A ductless gland that secretes hormones, which usually enter interstitial fluid and then the bloodstream.

**Endocytosis:** Movement of a substance into a cell by a vesicle.

**Endosperm:** Nutritive tissue that surrounds a flowering plant embryo and becomes food for the young seedling.

**Endospore:** A resting structure that forms around a copy of the chromosome and part of the cytoplasm of certain bacteria.

**Epiglottis:** A flap like structure at the start of the larynx, the position of which directs the movement of air into the trachea or of food into the esophagus.

**Epithelium:** An animal tissue of one or more layers of adhering cells that covers the body's external surfaces and lines its internal cavities and tubes.

**Essential amino acid:** An amino acid that an organism cannot synthesize for itself and must obtain from food source.

**Ethylene:** plant hormone that stimulate fruit ripening and abscission.

**Exocrine gland:** Secretes product, usually through ducts or tubes, to a free epithelial surface.

**Exocytosis:** Transport of a substance out of a cell by means of a vesicle.

## F

**FAD**: Flavin adenine dinucleotide, one of the nucleotide coenzymes that transfers electrons and unbound protons ( $H^+$ ) from one reaction site to another. At such times it is abbreviated FADH<sub>2</sub>.

**Fin**: Of fish generally, an appendage that help propel, stabilize, and guide the body through water.

**Fossil**: Recognizable, physical evidence.

**Fossil fuel**: Coal, petroleum and natural gas.

## G

**Gametes**: Sex cells, sperms and eggs.

**Ganglion**: Group of neuron outside CNS.

**Gene**: unit of information about a heritable trait that pass from parent cell to daughter cell.

**Genome**: All the DNA or genes in a single or haploid set of chromosomes of a given species.

**Germ cells**: Of animals, give rise to eggs and sperms.

**Gland**: A secretory cell or structure.

**Gonads**: Sex organs, that is testes or ovaries.

## H

**Habitat**: The type of place where an organism normally lives.

**Hermaphrodite**: An individual with both male and female gonads.

**Hormones**: Signaling molecule that stimulates or stop or modified cells having receptors for them.

## I

**Infection**: Invasion and multiplication of a pathogen in host cells or tissue.

**Integument**: Of animals, a protective body cover such as skin. Of seed-bearing plants, one or more layers around an ovule that form a seed coat.

**Invertebrate**: An animal without backbone.

## K

**Keratin**: A tough, water- insoluble protein made by most epidermal cell which becomes deposit in outer body coverings (skin).

## L

**Larva**: An immature developmental stage between the embryo and adult.

**Ligament**: A band of connective tissue that bridge a joint.

**Lymph**: Tissue fluid that has drained into the vessels of the lymph system.

## M

**Mutagen**: Any environmental agent that can alter the molecular structure of DNA.

**Mutation**: a heritable change in the molecular structure of DNA.

## N

**Necrosis**: Of multicelled organisms, the passive death of many cells that results from severe tissue damage.

**Nerve cord**: Of many animals, a cord like communication line of axons of neurons.

**Neuron**: A nerve cell; the basic unit nervous systems.

**Node**: A site where one or more leaves are attached to a plant stem.

**Nucleoid**: The region in bacterial cell where chromosome is located (but not bounded by

membrane)

**Nutrition:** All of those processes by which food is selectively taken in, digested, absorbed, and later converted to the body's own organic compounds.

## O

**Obesity:** An excess of fat in the body.

**Ovum:** The mature female egg (ovum)

## P

**Parasitism:** A two species interaction in which one species lives in or on a host species and uses its tissue for nutrients. The parasite benefits; the host damage.

**Passive transport:** The movement of substances from higher to lower concentration without energy.

**Pathogen:** A disease causing organism.

**Perennial:** a flowering plant that lives for more than two growing season.

**Phloem:** Of vascular plants, a tissue with living cell that inter connect and form the tubes through which sugars and other dissolved organic compounds are conducted.

**Phycobillin:** One of the light sensitive, accessory pigments that transfer energy they absorb to chlorophylls, abundant in red algae and cyanobacteria.

**Phytoplankton:** A community of floating or weekly swimming phytoautotroph in salt and fresh water habitat.

**Pigment:** A light absorbing molecule.

**Plankton:** Any community of floating or weekly swimming organisms, mostly microscopic.

**Plasmolysis:** an osmotically induced shrinkage of a cell's cytoplasm.

**Pollen tube:** A tube formed after a pollen grain germinates; grows through carpel tissues, and carries sperm to the ovule.

**Pollination:** The arrival of pollen grain on the stigma of carpel ( in seeded plants)

**Predators:** An organism that feeds on another organism.

## R

**Rhizoid:** A root like absorptive structure of some fungi and in nonvascular plants.

## S

**Salts:** A compound that releases ions other than  $H^+$  and  $OH^+$  in solution.

**Saprobs:** A heterotroph that obtains energy and carbon from non living organic matter so cause it's decay. E.g., fungi and bacteria.

**Secretion:** A product release across the plasma membrane of a cell that may act singly or as a part of glandular tissue.

**Semen:** sperms bearing fluid expelled from a penis during male orgasm.

**Solute:** Any substance dissolved in solution (in water)

**Solvent:** A fluid, such as water, in which one or more substances is dissolved.

**Somatic cell:** A body cell that is not a germ cell (which give rise to egg and sperm).

**Sperm:** A type of mature male gametes.

**Spleen:** It is lymphoid organ; also filtering station for blood, a reservoir of red blood cells and macrophages.

**Stamen:** A male reproductive structure in a flower.

**Stem cell:** A type of cell perpetuating cell that remains unspecialized.

## T

**Tendon:** A strap of dense connective tissue that attaches muscle to bones.

**Tracheid:** One of two types of cells in xylem that conduct water and dissolved minerals.

**Transcription:** The first stage of protein synthesis; when a RNA strand is assembled from one two strand of DNA.

**Transpiration:** In the presence of sun light, evaporation of water from above ground plant parts, leaves especially.

## V

**Vascular plants:** A plant with a transport system i.e., xylem and phloem,

**Vascular tissue:** Xylem and phloem.

**Vertebrates:** Animal with a backbone.

**Vesicle:** In cytoplasm of cells, one of variety of small membrane bound sac that function in the storage, transport and digestion of substances or in some other activity.

**Vitamin:** Any of more than ten substances that animals require in small amount for metabolism.

## W

**Water Potential:** The tendency of water molecules to move from one region to another. The greater the difference in water potentials between two regions, the greater and faster the net movement of water molecules from a region of higher water potential to a region of lower water potential.

**White blood cell:** One type of blood cell. It is colorless and has a nucleus. It helps to keep the body healthy by fighting germs.

**Wilting:** A process by which the leaves lose water (as water vapour) faster than the roots absorb water and mineral salts from the roots to the root hair cells lose water to the very dry soil.

## X

**Xylem:** A tissue that transport water and solutes through the vascular plants.

## Y

**Yeast:** A tiny, oval, unicellular organism which does not contain chlorophyll. It reproduces by budding and can respire under anaerobic conditions.

## Z

**Zooplankton:** A freshwater or marine community of floating or weakly swimming heterotroph (animal).

**Zygote:** The first cell of new individual, formed by the fusion of nuclei of gametes at fertilization.