

# **Introduction to Immunology**

**CLS 212: Medical Microbiology**

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# What is Immunity?

## Immunity:

- Is a biological term that describes a state of having sufficient **biological defenses** to avoid infection, disease, or other unwanted biological invasion.
- In other words, it is nothing but the **capability of the body to resist harmful microbes from entering the body.**

## Immunology:

The study of all aspects of the immune system in all organisms.

# Types of Immunity

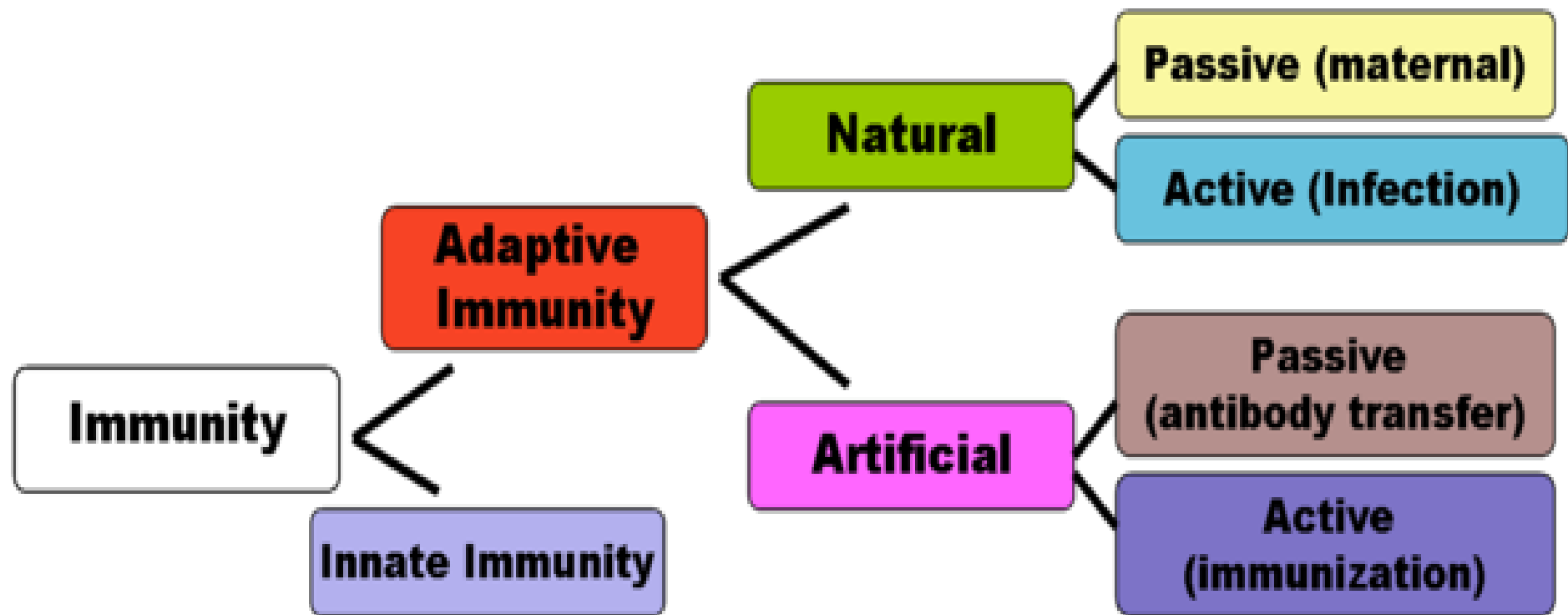
## **Nonspecific Immunity: (Innate immunity)**

Is the natural resistance with which a person is born. It provides resistance through several physical, chemical, and cellular approaches.

## **Specific Immunity: (Acquired/Adaptive immunity)**

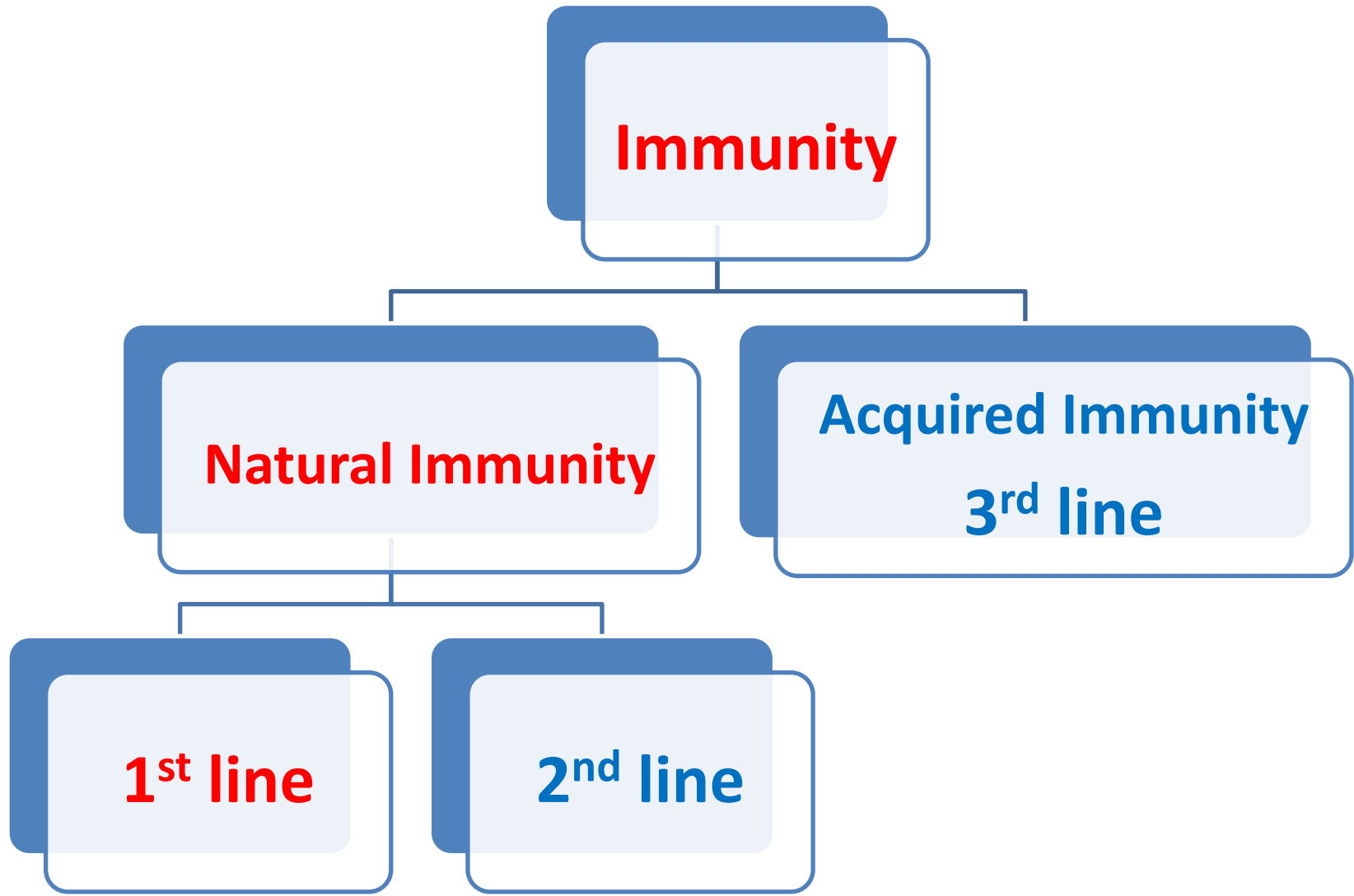
Is often sub-divided into two major types depending on how the immunity was introduced:

- **Naturally acquired immunity:** occurs through contact with a disease causing agent, when the contact was not deliberate.
- **Artificially acquired immunity:** develops only through deliberate actions such as vaccination.



# Three Lines of Defense Against Infection

NONSPECIFIC DEFENSE MECHANISMS		SPECIFIC DEFENSE MECHANISMS (IMMUNE SYSTEM)
First line of defense	Second line of defense	Third line of defense
<ul style="list-style-type: none"><li>• Skin</li><li>• Mucous membranes</li><li>• Secretions of skin and mucous membranes</li></ul>	<ul style="list-style-type: none"><li>• Phagocytic white blood cells</li><li>• Antimicrobial proteins</li><li>• The inflammatory response</li></ul>	<ul style="list-style-type: none"><li>• Lymphocytes</li><li>• Antibodies</li></ul>



# **1<sup>st</sup> Line of Defense**

- 1. Skin and mucous membranes.**
- 2. Cellular and chemical factors.**
- 3. Microbial antagonism.**

# Skin and Mucous Membranes

- The intact (unbroken) skin or mucous membranes serves as a physical or mechanical barrier to pathogens.
- Very few pathogens can penetrate intact skin **e.g.** parasites like schistosomes and hookworms.
- Mostly pathogens can get entry only when skin or mucous membranes are **cut, scratched, or burned**. Or through skin **injections** by needles or insects.
- Even the smallest cut (e.g. paper cut) can serve as an entry for pathogens.
- The sticky mucus produced by special cells in the mucous membranes will trap invaders.



# I- Skin Cellular and Chemical Factors

1. Dryness of the skin.
  2. Temperature of the skin (<37°C).
  3. Acidity of the skin ( $\approx$  5.0 pH).
  4. Oil production by sebaceous glands.
  5. Sweat flushes pathogens and contain *Lysozyme enzyme* which kills pathogens.
  6. Shedding of dead skin.
- All these factors will inhibit the growth of pathogens.

## II- Mucous Membranes Cellular and Chemical Factors

1. **Mucus:** sticky and contain enzymes (Lysozyme, Lactoferrin, Lactoperoxidase).
2. **Eyes:** tears (Lysozyme enzyme), mucus, and oil.
3. **Respiratory System:**
  - a. Nose hair.
  - b. Irregular nose chambers.
  - c. Nasal secretions.
  - d. **Cilia:** push foreign bodies (dust, smook, pathogens) up the to the throat where they are swallowed or expelled by coughing and sneezing.

## II- Mucous Membranes Cellular and Chemical Factors

### 4. Digestive System:

- a. Oral saliva.
- b. Digestive enzymes.
- c. Stomach acidity (pH 1.5).
- d. Intestinal alkalinity by liver bile.

5. Urinary System: flow of acidic urine and mucus.

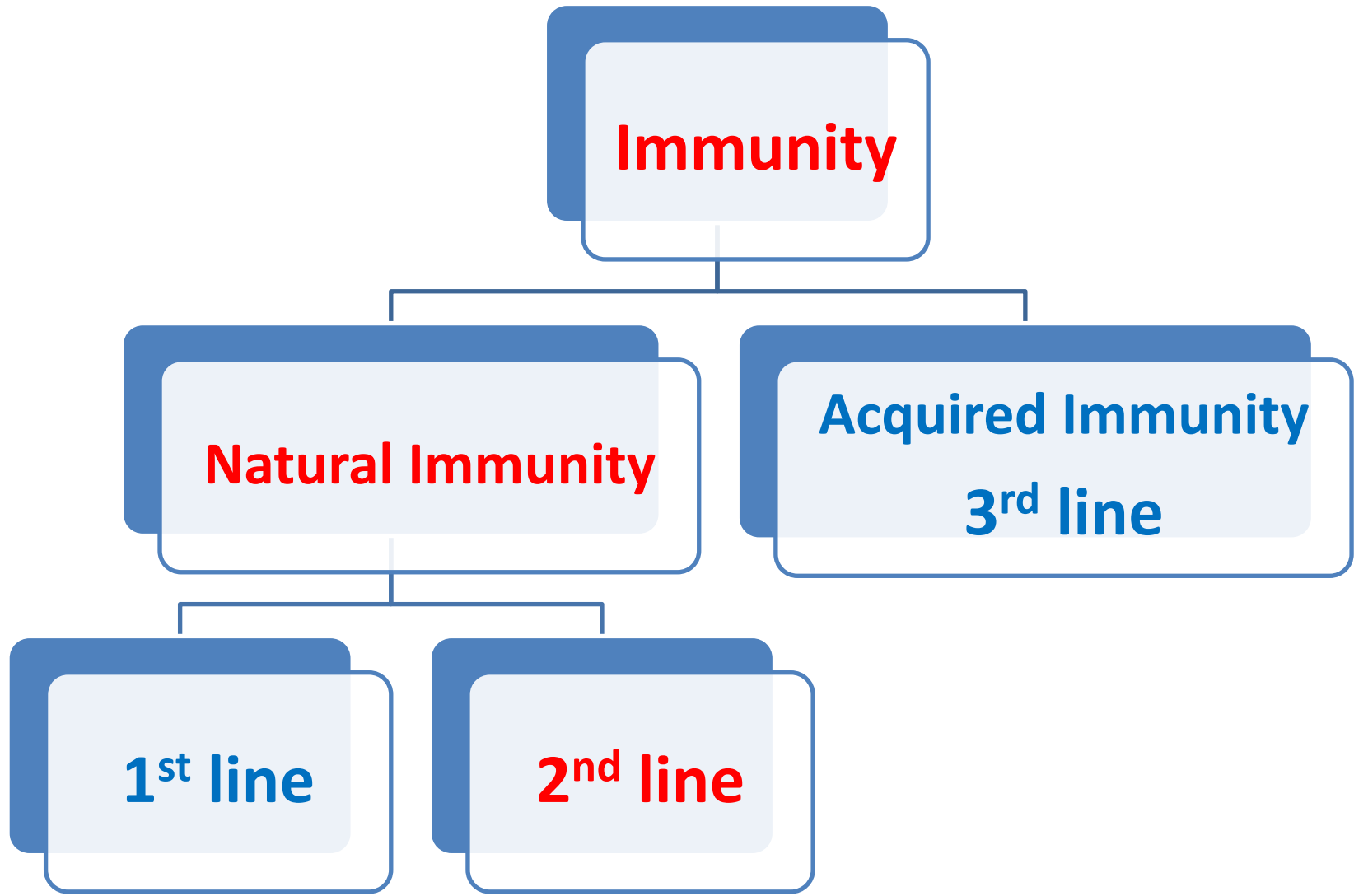
6. Female vagina: low pH of vaginal fluids.

# III- Microbial Antagonism

## Microbial Antagonism:

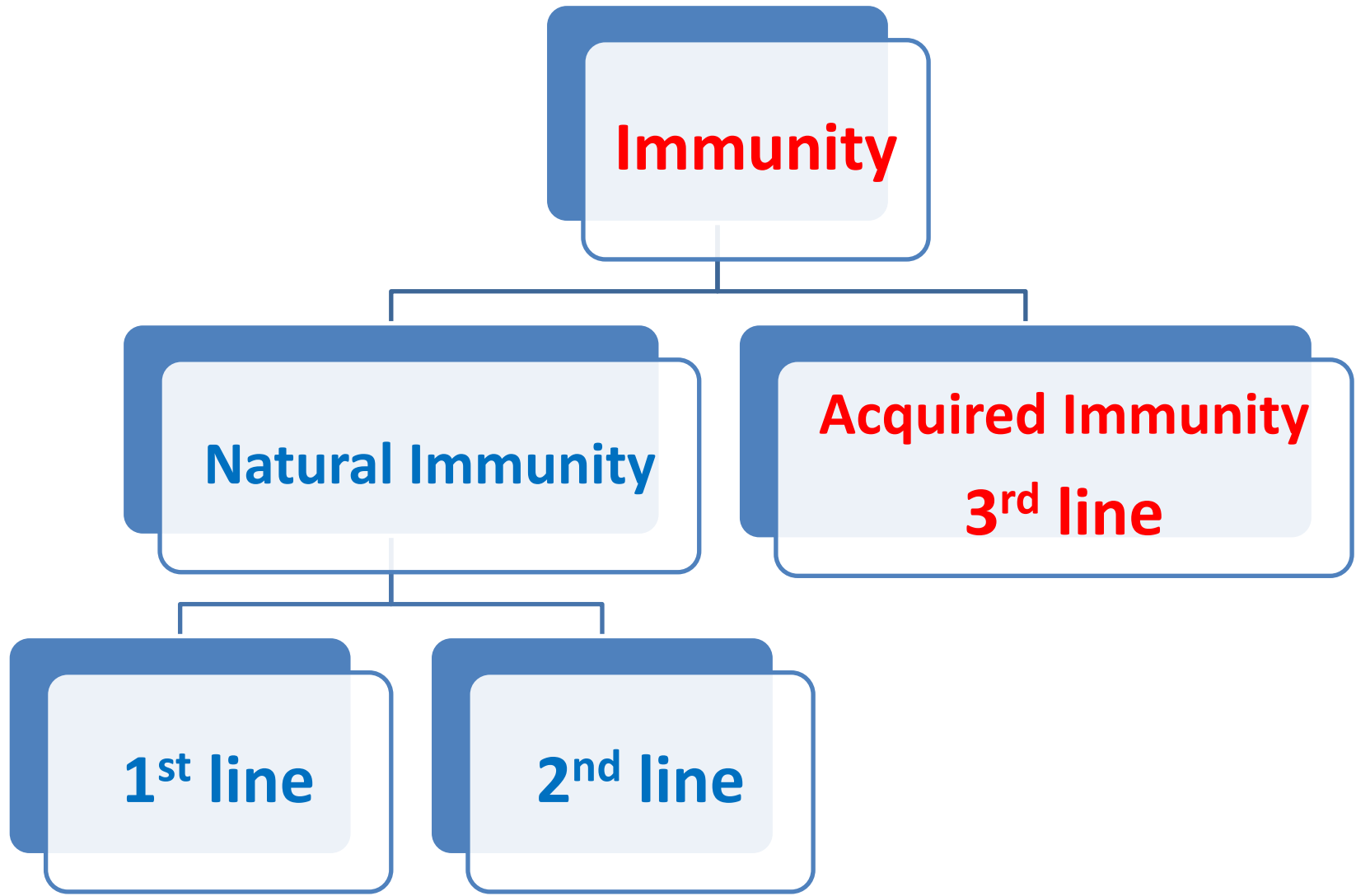
When one microorganism kill, injure, or inhibit the growth of another microorganism.

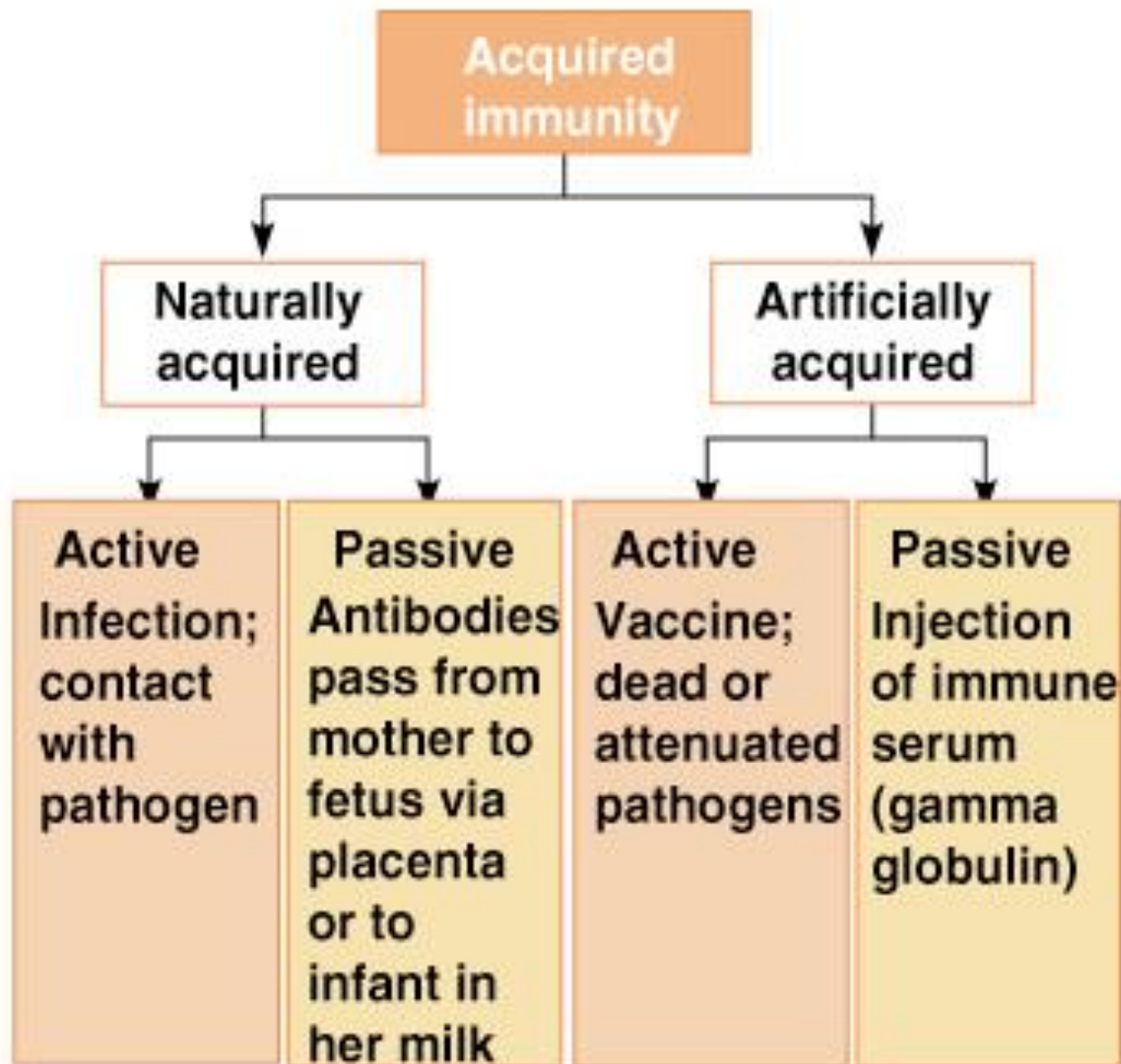
- This is done by resident **Normal Flora** that prevent colonization of pathogens in a body site by:
  1. Competition for colonization sites.
  2. Competition for nutrition.
  3. Production of substances that kills pathogens.
- Antagonism decreases after prolonged use of broad-spectrum antibiotics.



## 2<sup>nd</sup> Line of Defense

1. **Transferrin:** takes iron from pathogens.
2. **Fever (>37°C):** stimulate WBCs, reduce blood iron, and inhibit attachment of pathogens.
3. **Interferons:** produced by virus-infected cells to stop spreading of infection.
4. **The complementary system:** a group of 30 proteins that work together to destruct pathogens.
5. **Acute-phase proteins:** resist infection and stimulate repair of damaged tissues.
6. **Cytokines:** act as chemical messengers within immune system and between it and body systems.
7. **Inflammation:** body response to injury, irritation, microbial attack, or bacterial toxins. **Signs are:** redness, heat, swelling, and pain.
8. **Phagocytosis:** the process of surrounding and engulfing foreign materials.

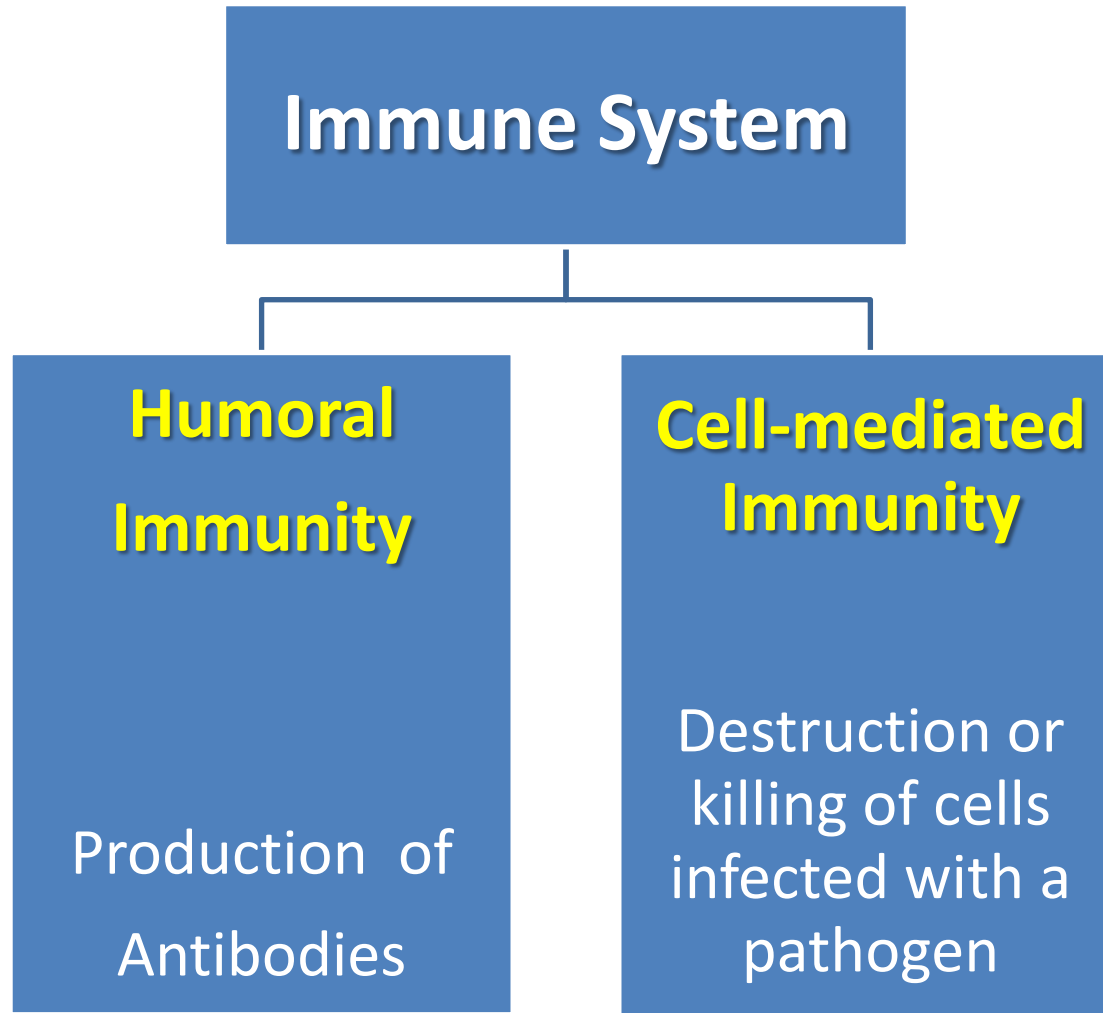






# Types of Acquired Immunity

## Based on Cell Response

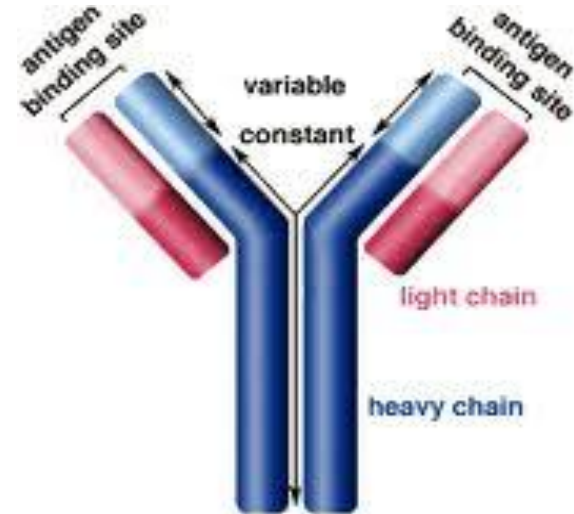


# 1-Humoral Immunity

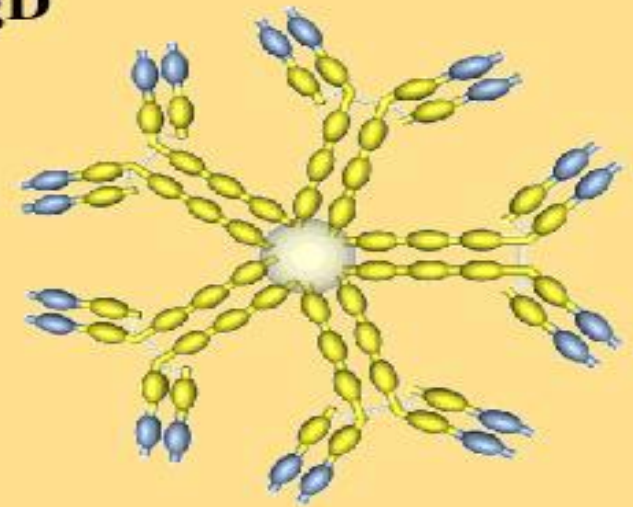
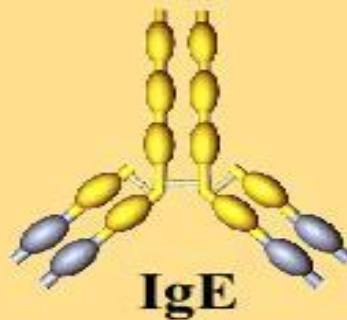
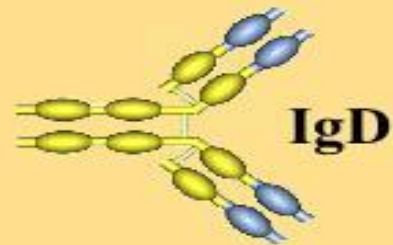
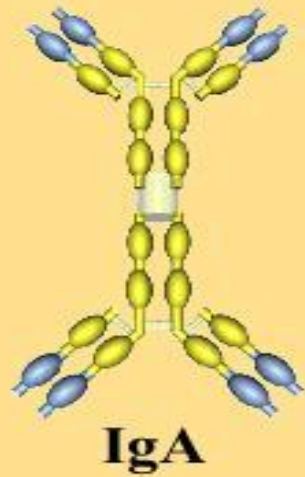
- **Antigens:** any agent (microorganism, molecule, protein...etc) that can stimulate the production of antibodies.
- **Antibodies:** Specific glycoproteins produced by B-lymphocytes in response to the presence of an antigen.

➤ *All antibodies are in a class of proteins called Immunoglobulins.*

➤ *Each antibody is specific to the antigen that stimulates its production.*



# Different Classes of Immunoglobulins

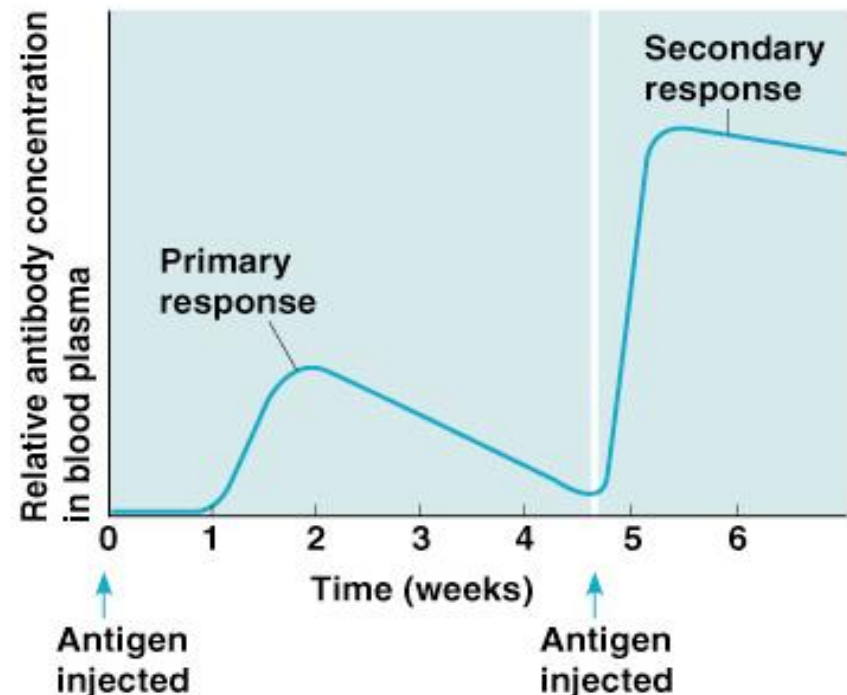


# Primary vs. Secondary Immune Response

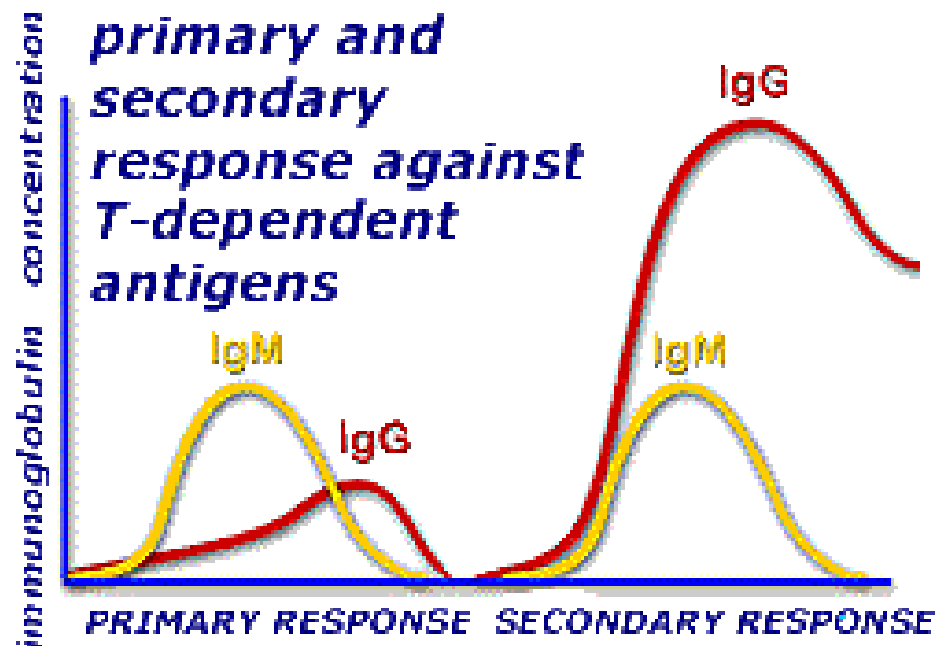
The initial immune response to a particular antigen is called **Primary Response**, It takes approximately 10 to 14 days for antibodies to be produced.

Primary response result in the production of memory cells

The second immune response to the same antigen is called **Secondary Response**, it is characterized by large quantities of antibodies which take less time to be developed than primary immune response.



# IgM and IgG Titer in Primary and Secondary Immune Response to the Same Antigen



**IgM:** is high at the 1<sup>st</sup> administration of antigen in the body.

**IgG:** is created at the end of primary immune response and called memory cells, and is greatly increased in the secondary immune response.

# **HUMORAL IMMUNE RESPONSE**

## Activation Phase

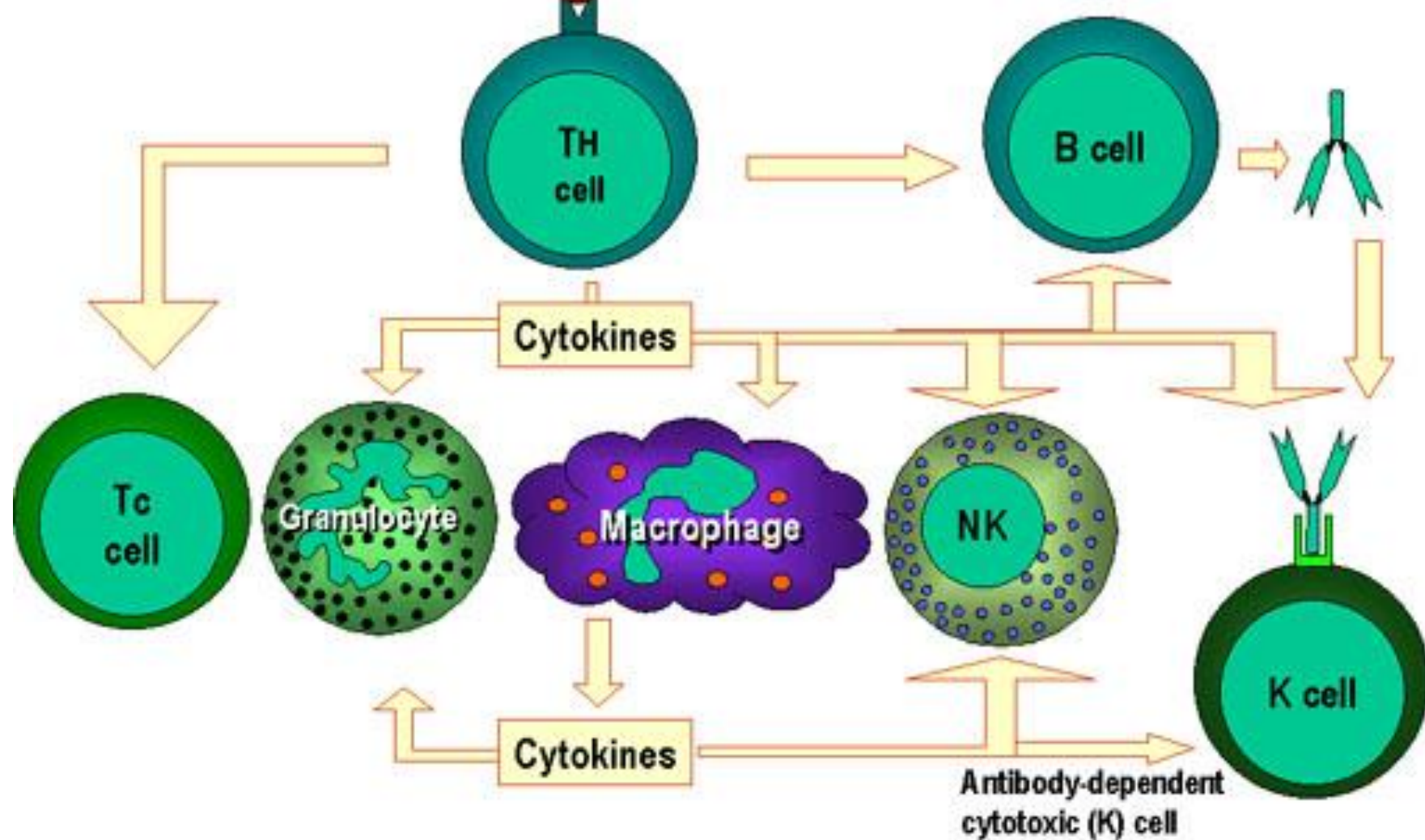
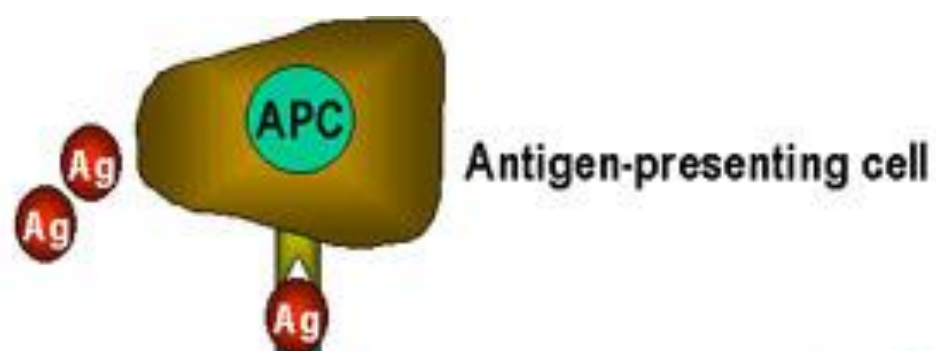
## 2- Cell-Mediated Immunity

- Antibodies are unable to enter cells, including cell containing intracellular pathogens. Fortunately, there is a part of the immune system capable of controlling chronic infections caused by intracellular pathogens. It is called **Cell Mediated Immunity (CMI)**- *a complex system of interactions between many types of cells and cellular secretions (cytokines).*

# Cells that Participate in CMI

- Macrophages
- Natural killer cells (NK)
- Granulocytes
- T-Lymphocytes:
  - \* T-helper cells
  - \* T-cytotoxic cells
  - \* T-killer cells



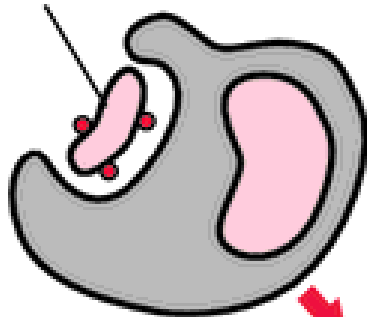


# Atypical Cell-mediated Cytotoxic Response Involve the following steps:

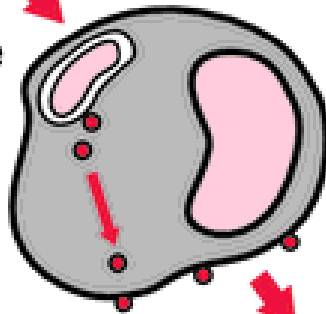
- **Step1:** A macrophage engulfs and partially digests a pathogen. Fragments (antigenic determinants) of the pathogens are then displays on the surface of the macrophage.
- **Step2:** A T-helper cell binds to one of the antigenic determinants being displayed on the macrophage surface. The T-helper produces cytokines which reach an effector cell of the immune system (e.g. **T-cytotoxic cell**, NK cell, or T-killer cell).
- **Step3:** The effector cell binds to the pathogen infected host cell displaying the same antigenic determinant on its surface.
- **Step4:** The effector cell will produce perforin and other proteins/enzymes, which literally punch holes in the target cell membrane causing it to dye.

# Activation of T-lymphocytes

Foreign microbe  
with antigens



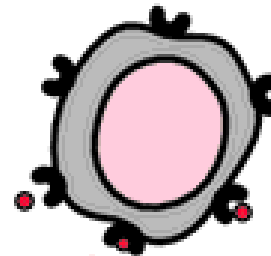
Macrophage  
ingests  
antigens...



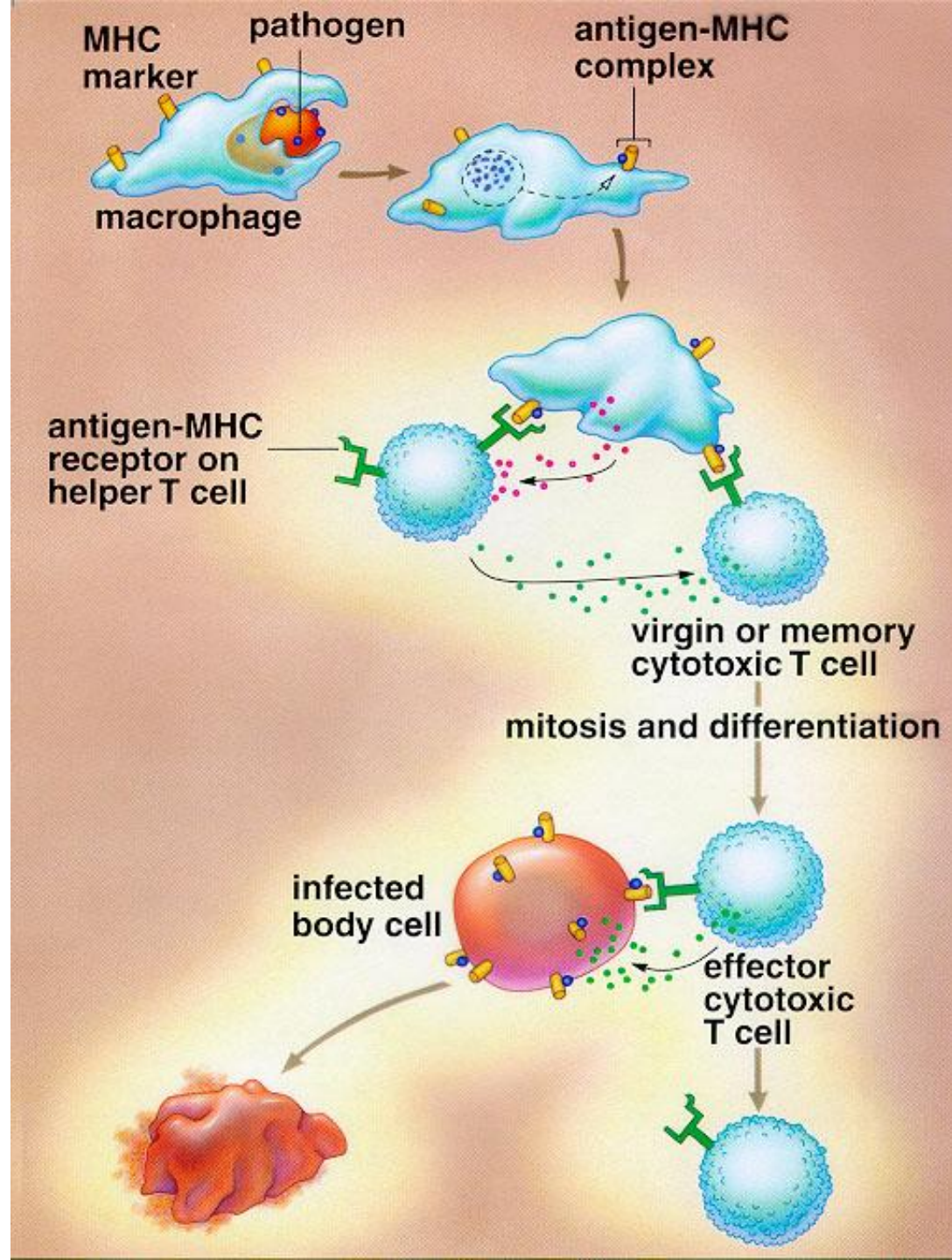
Processes  
them...



T-cell



and presents  
them to the T-cell



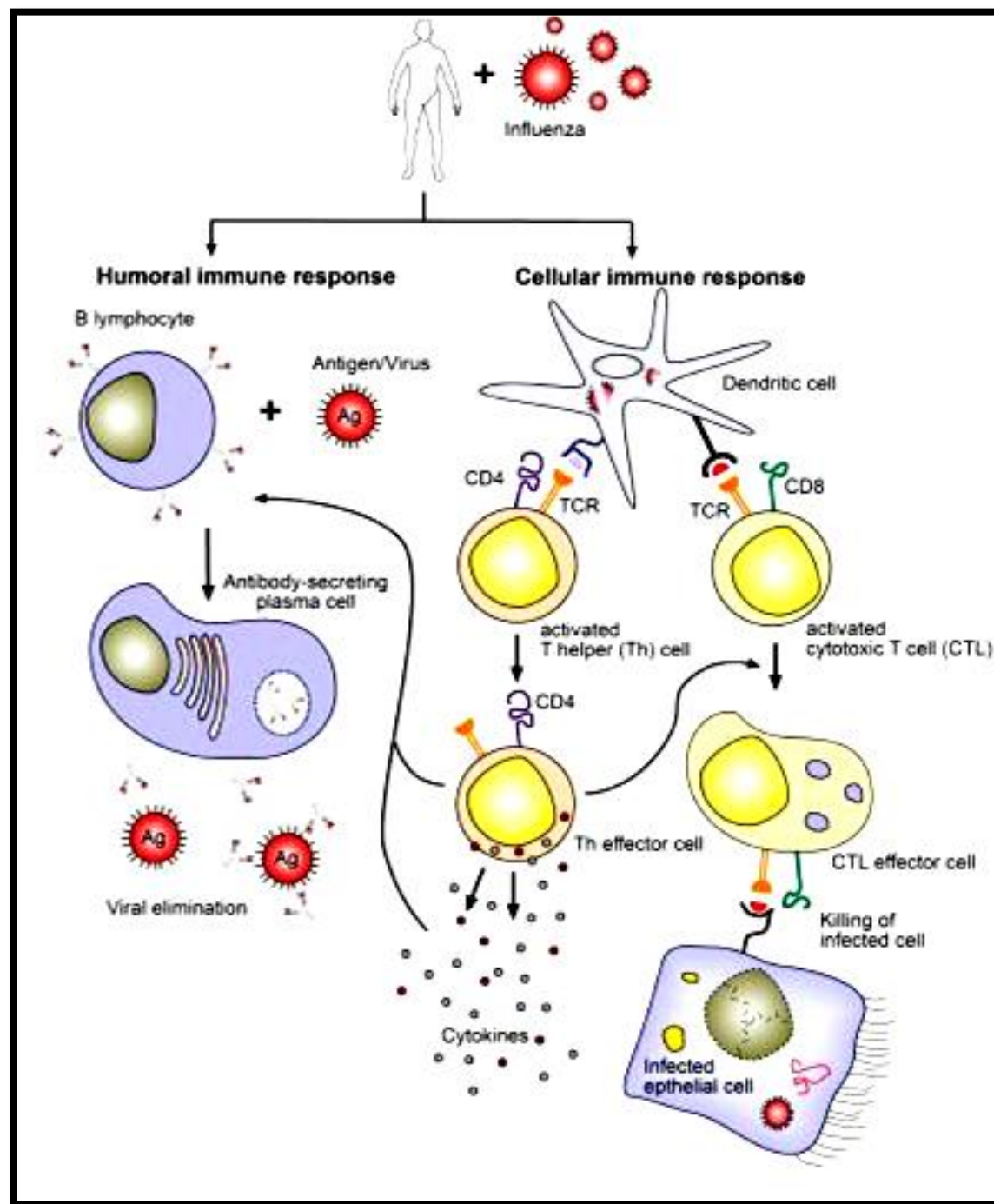
# **CELLULAR IMMUNE RESPONSE**

## **Activation phase**

# Relationship Between Cell-Mediated and Humoral Immunity

- Although **CMI** does not involve the production of antibodies, antibodies produced during humoral immunity may play a minor role in some cell-mediated responses.
- *The AIDS virus (HIV) that targets T-helper cells impairs both Humoral and Cell-mediated Immunity, making person infected with AIDS very susceptible to many opportunistic infections and malignancies.*





# Immunosuppression

- If a person's immune system is functioning properly, that person is said to be an **immunocompetent** person. If a person's immune system is not functioning properly, that person is said to be **immunosuppressed**, **immunodepressed** or **immunocompromised**.

