



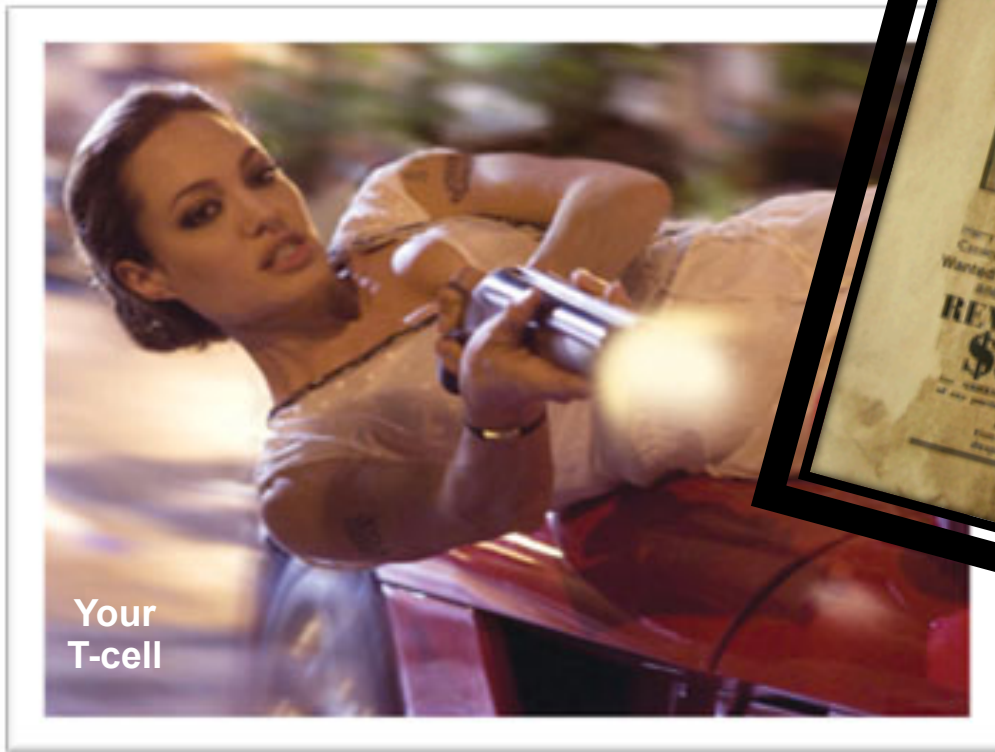
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Immune System II: Acquired Immunity



Images: : Angelina Jolie as assassin in movie
Wanted; Wanted poster, source unknown



1st Line of Immune Defense INNATE

Structures and chemicals that form the first barrier protecting us from infectious disease.

Physical: 1. _____

2. _____

Chemical: 1. _____

2. _____

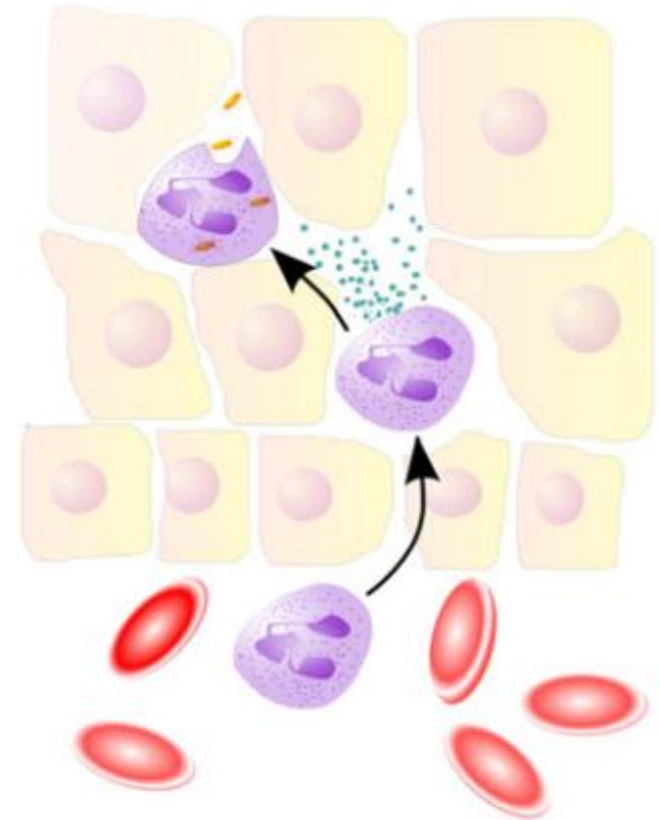


First Line of Defense



2nd Line of Immune Defense ACQUIRED

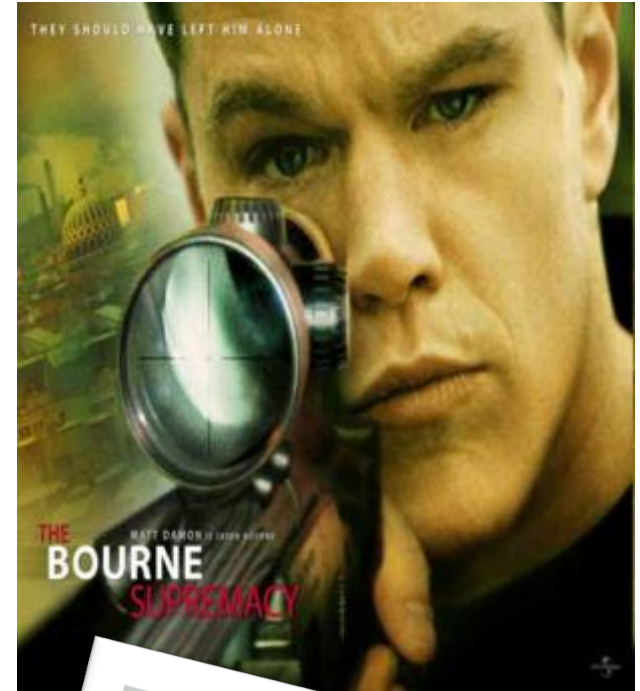
- In play when pathogens penetrate the skin or mucous membranes.
- Composed of cells, antimicrobial chemicals, and processes but **no physical barriers**.
- Many of these components are contained or originate in the blood.
- Includes:
 1. Leukocytes involved in nonspecific immune defense usually do one of two things:
 - a. _____
 - b. _____
 2. Nonspecific _____ defenses.
 3. _____
 4. _____



Second Line of Defense

Third Line of Defense - Acquired

- The body's ability to recognize and defend itself against distinct invaders.
 - Is a "smart" system.
 - Also called **specific** and **adaptive** immunity.
 - "Memory" allows it to respond rapidly to additional encounters with a pathogen.
 - If nonspecific immune system has *warriors*, then acquired immunity has more sophisticated *special agents* and *assassins*.
- Two types of specific immunity:
 - Naturally acquired = immune response against antigens encountered in daily life.
 - Artificially acquired = response to antigens introduced via vaccine.
- **Q:** *How does the body recognize invaders?*



Third Line of Defense

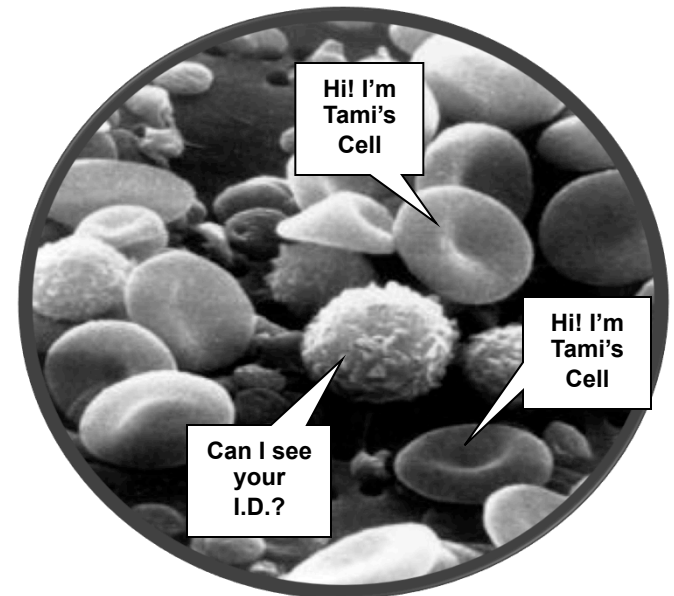
Antigens

- Body does not direct immune response against whole bacteria, fungi, protozoa or viruses.
- Foreign molecules trigger a specific immune response.
- Include components of bacterial cell walls, capsules, pili, and flagella, as well as proteins of viruses, fungi and protozoa.
- Food and dust can also contain antigenic particles.
- Enter the body by various methods:
 - Through breaks in skin & mucous membranes
 - Direct injection, as with a bite or needle
 - Through organ transplants and skin grafts

HELLO
my name is

Antigens Are Like Name Tags

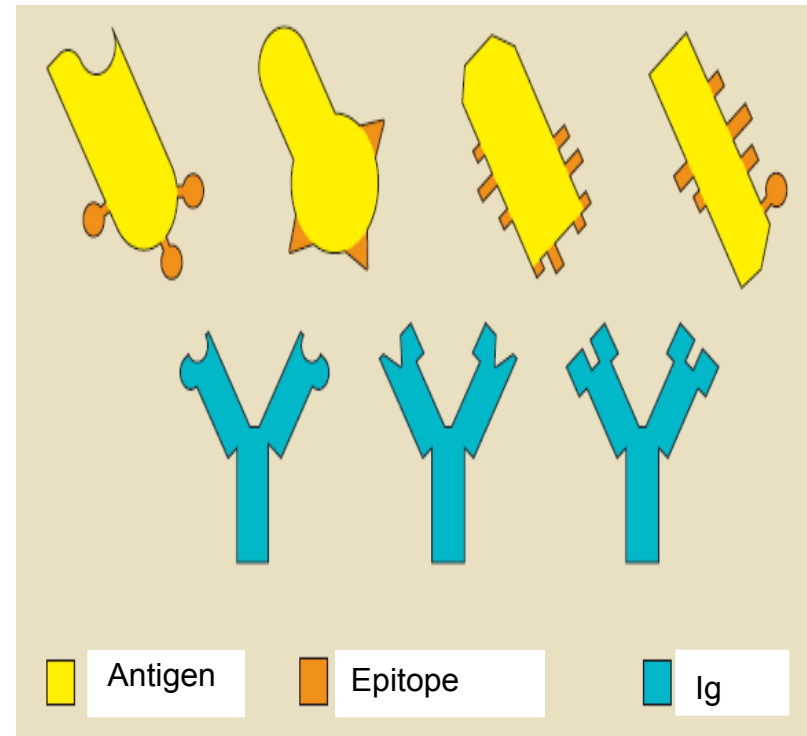
Antigenic particles are often associated with a specific characteristic of an organism, so are detected as foreign when they get inside another organism that doesn't have that characteristic.



Third Line of Defense

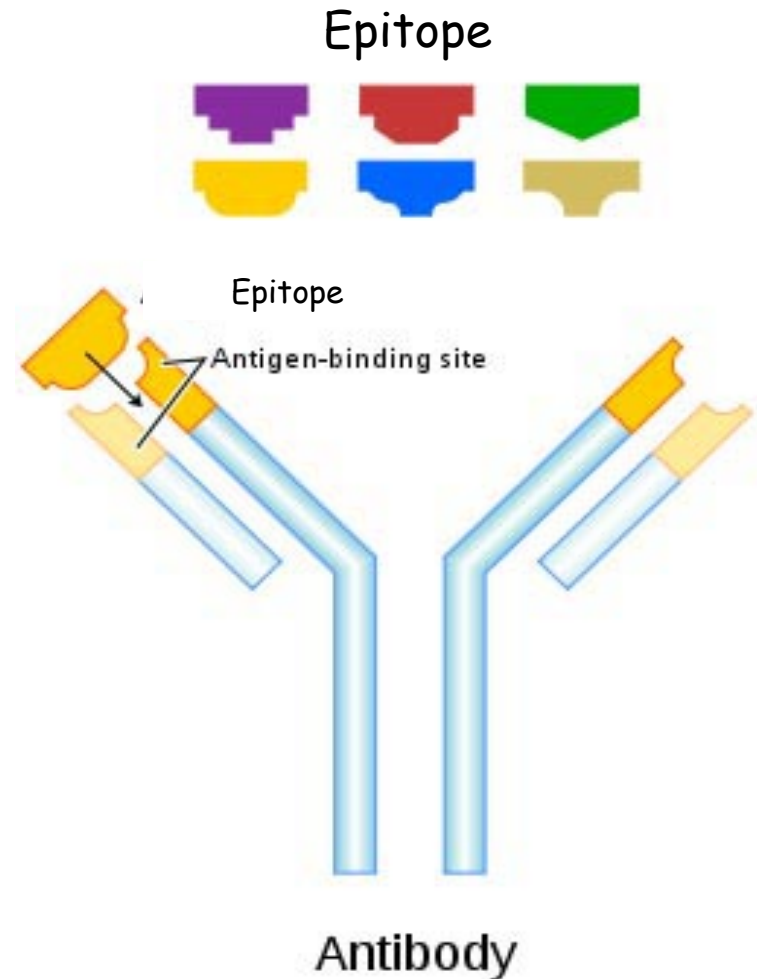
Antigens

- The part of the antigen that is recognized by the immune system is called an **epitope** (or antigenic determinant).
- An antigen may have several epitopes
- Types of antigens:
 - Exogenous: Toxins and other secretions and components of microbial cell walls, membranes, flagella and pili.
 - Endogenous: Microbes that reproduce inside infected cells produce endogenous antigens. Can only be seen by the immune system if incorporated into the host cell's plasma membrane.
 - Autoantigens: aka “self-antigens”. Antigen molecules found on an individual's normal, uninfected cells. (i.e. nametags saying “I am part of the body.”)



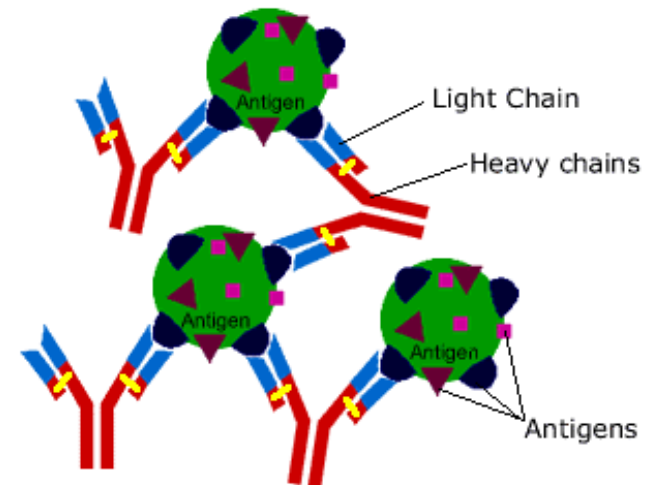
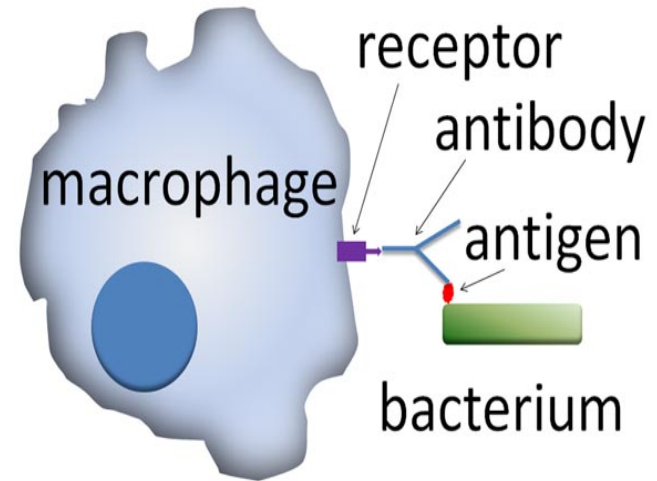
Antibodies

- Also called immunoglobulins (Ig).
- Proteinaceous molecules that bind antigenic determinants at the antigen-binding site.



How Antibodies Work

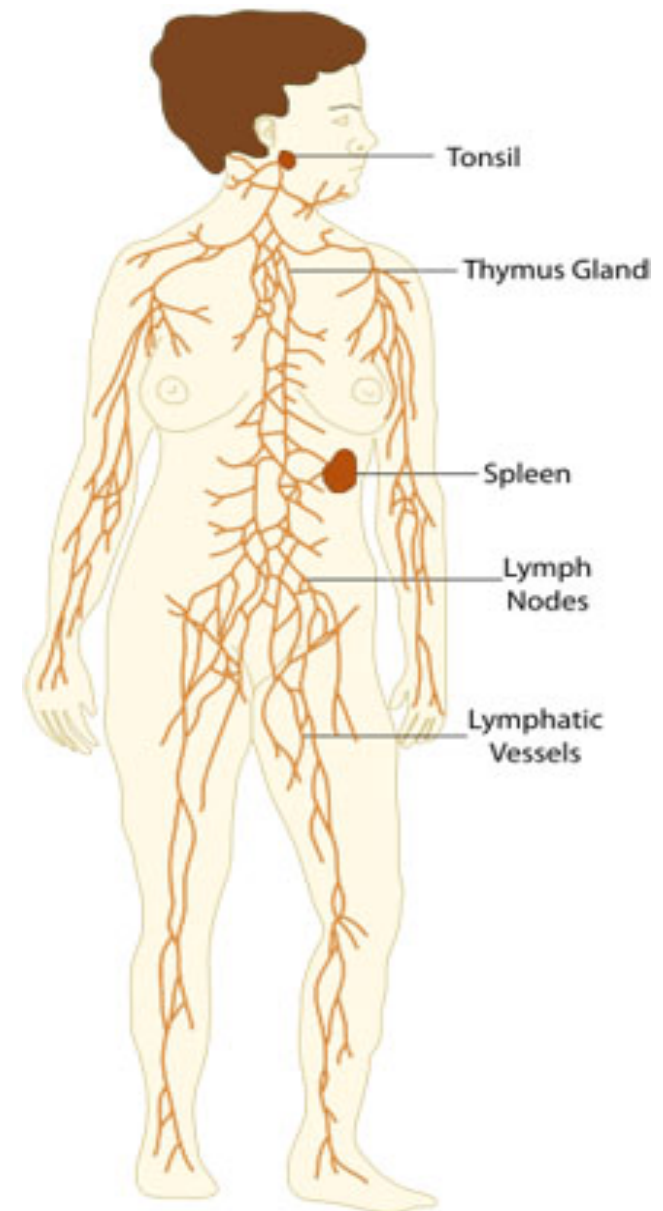
- Some act as **opsonins**, markers to identify antigens for phagocytes and stimulate phagocytosis.
- Some work as **antitoxins** (i.e. they neutralize toxins for e.g. those causing diphtheria and tetanus).
- Some attach to bacterial flagella making them less active and easier for phagocytes to engulf.
- Some cause **agglutination** (clumping together) of foreign cells making them less likely to spread



Q: *But where do antibodies come from?*

Lymphatic System

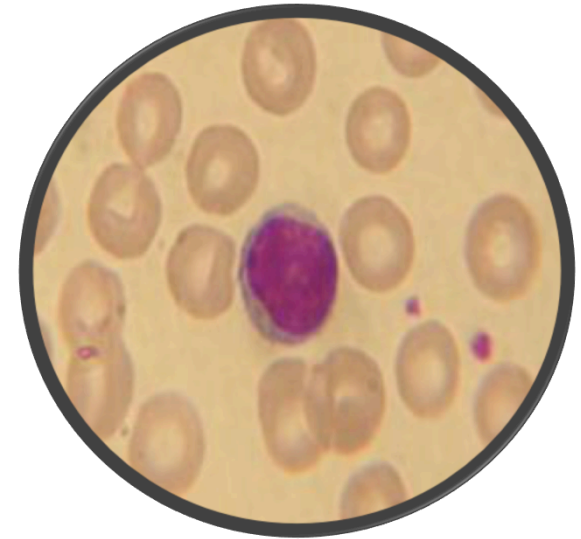
- Screens tissues of the body for foreign antigens.
- Composed of lymphatic vessels and lymphatic cells.
- One-way system that conducts lymph from local tissues and returns it to the circulatory system.
 - Lymph is a liquid with similar composition to blood plasma.
 - Comes from fluid leaked from blood vessels into surrounding tissues.
- Lymph nodes house white blood cells called **lymphocytes** that recognize and attack foreign antigens present in lymph.



Third Line of Defense



Lymphocytes



- WBCs of specific immunity. The smallest [leukocytes](#). Have huge nucleus surrounded by thin rim of cytoplasm.
- Produced from blood stem cells in the red bone marrow.

Two main types:

- **B-cells** mature in bone marrow, then concentrate in lymph nodes & spleen.
- **T-cells** mature in thymus.
- B and T cells mature then circulate in the blood and lymph.
- Circulation ensures they come into contact with pathogens and each other.
- B cells are a type of **Antigen Presenting Cell**.

What Is an Antigen Presenting Cell?

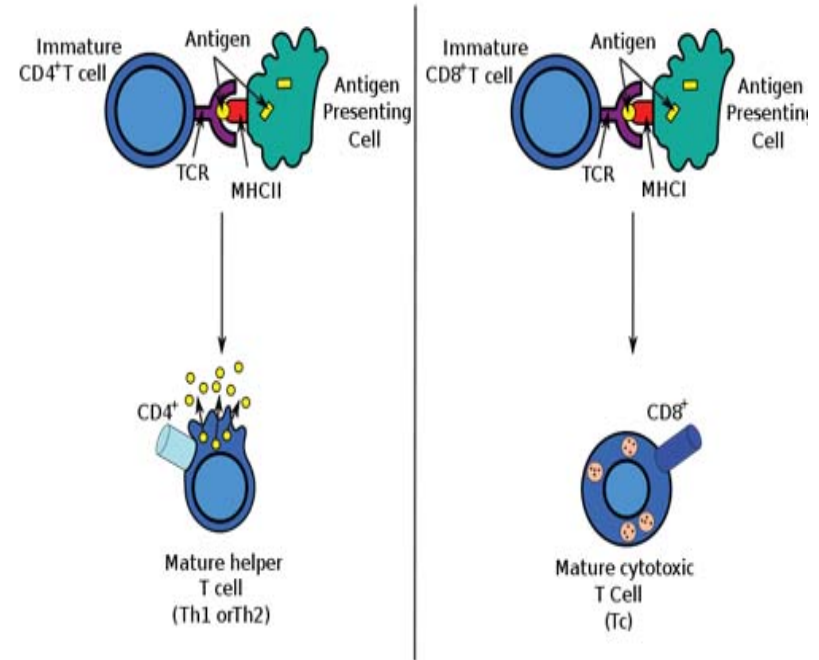
Consider your WBCs as a **security force** for your body and any non-self antigens as **pictures of a bad guy**.

The larger the force, the more likely one of the officers will run into a “bad guy” and so that the body will be able to apprehend it.

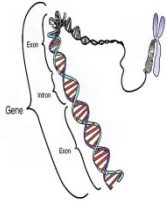
But sometimes different branches of law enforcement need to work cooperatively in order to catch a criminal. (Think about the FBI putting a picture of a wanted criminal on INTERPOL ... the International Criminal Police Organization).

Any WBC that can grab and present an antigen to another, is called an Antigen Presenting Cell (APC).

APCs include **B cells**, **macrophages** and **dendritic cells**.

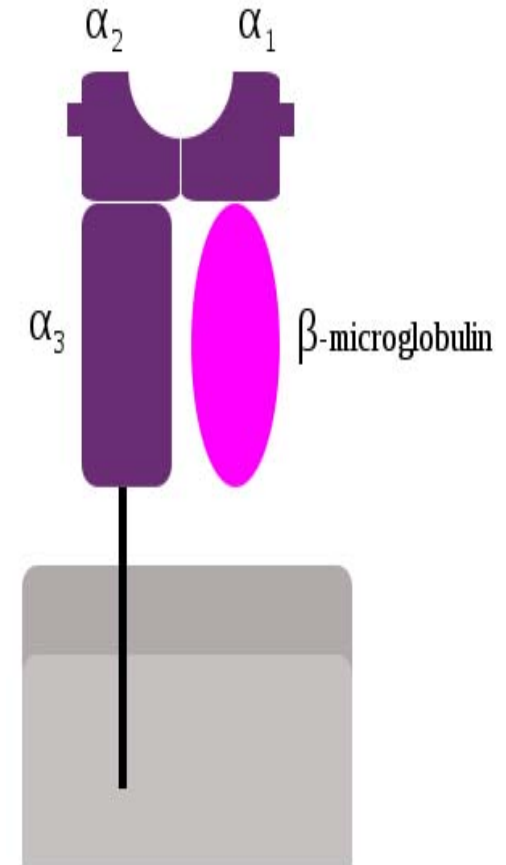


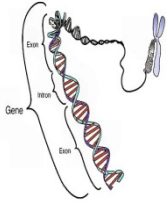
Third Line of Defense



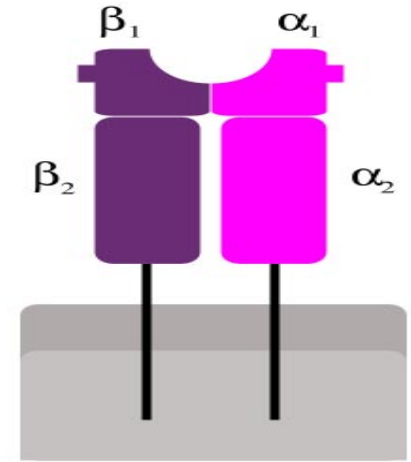
Major Histocompatibility Complex (MHC)

- Collection of **genes on chromosome 6**, which code for major histocompatibility glycoproteins.
- **MHC1** proteins are in the plasma membrane of all your nucleated cells (non-professional APCs).
- Since every human (other than identical twins) is genetically unique, MHC1 proteins differ between individuals.
- This is why you can only accept certain blood types for transfusions and why organ transplants are sometimes rejected.

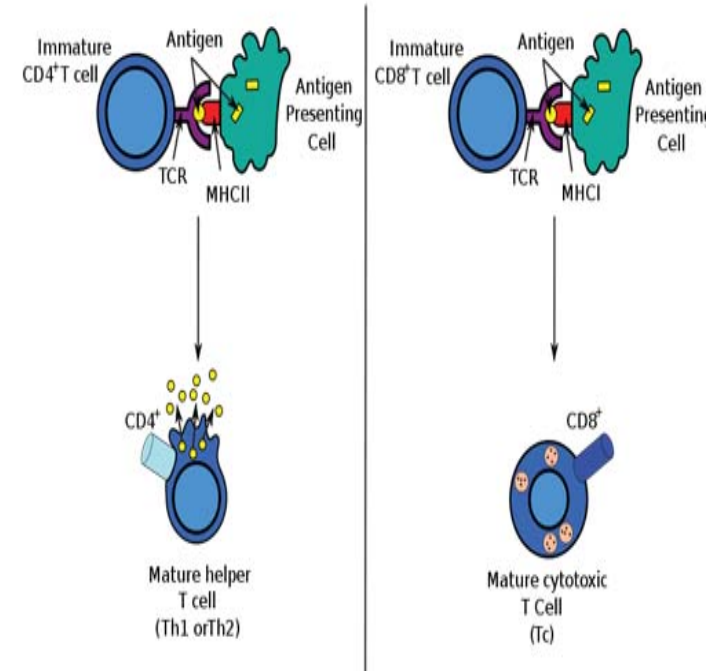




Major Histocompatibility Complex (MHC)

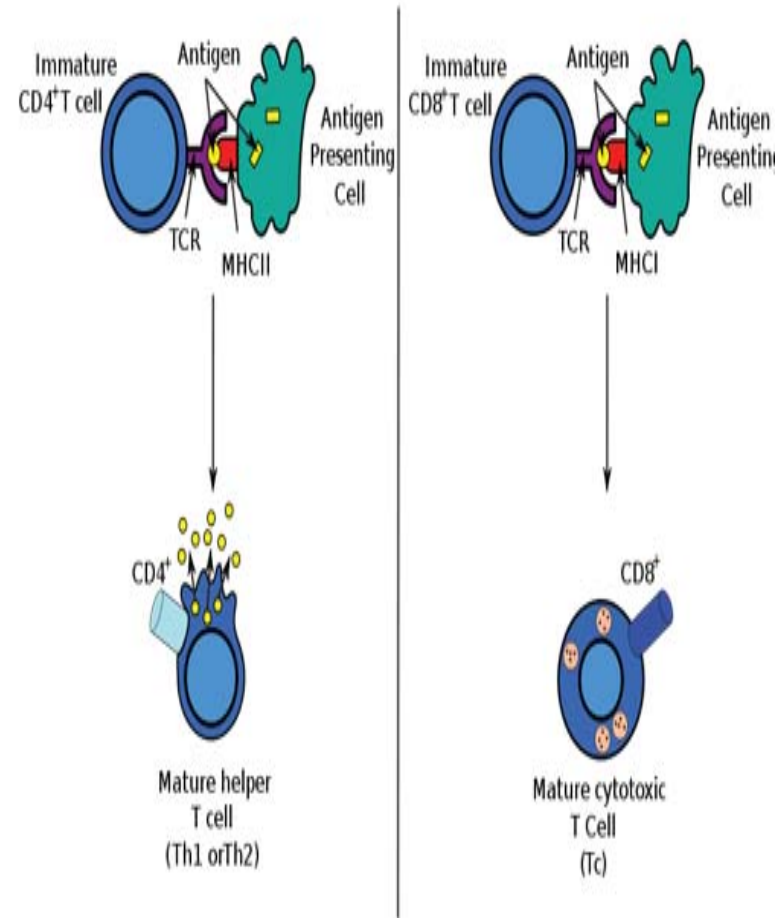


- **MHC2** proteins are found only in the plasma membrane of B cells and other professional antigen presenting cells, such as macrophages & dendritic cells.
- MHC glycoproteins function to hold and position antigenic determinants for presentation to other cells. (Think of them as antigen holders.)
- Some lymphocytes only recognize antigenic determinants that are bound to MHC molecules.



T Lymphocytes (T cells) & the Cellular Immune Response

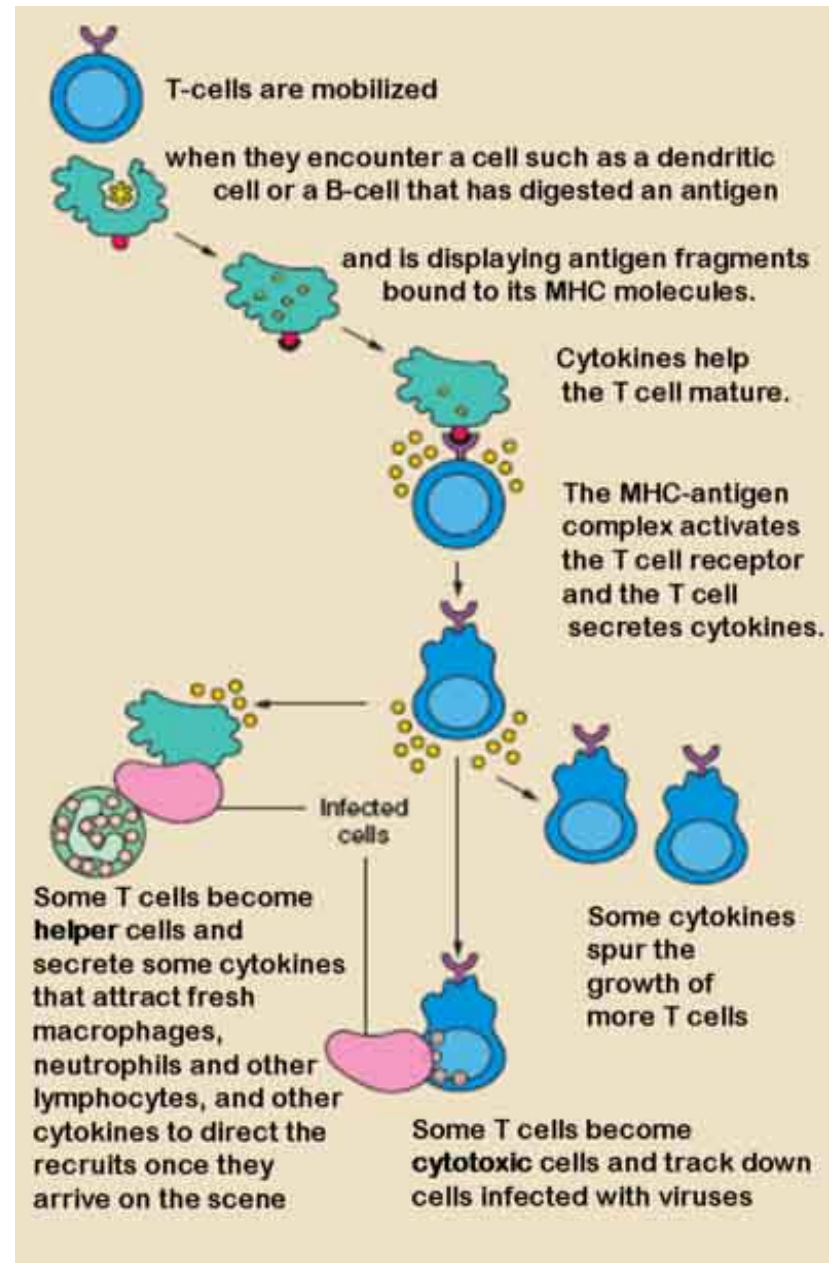
- Produced in red bone marrow and mature in thymus.
- Circulate in the lymph and blood and migrate to the lymph nodes (and other areas of the lymph system).
- Part of the cellular immune response (aka cell-mediated immune response) because these cells act directly against various antigens.
 - Endogenous invaders (intracellular pathogens inside the body's cells)
 - Abnormal body cells such as cancer cells
- Activation Phase & Effector Phase
- Activated T-cells differentiate into:
 - **cytotoxic** or **killer** T cells (T_C)
 - **helper** T cells (T_H)
 - **memory** T-cells

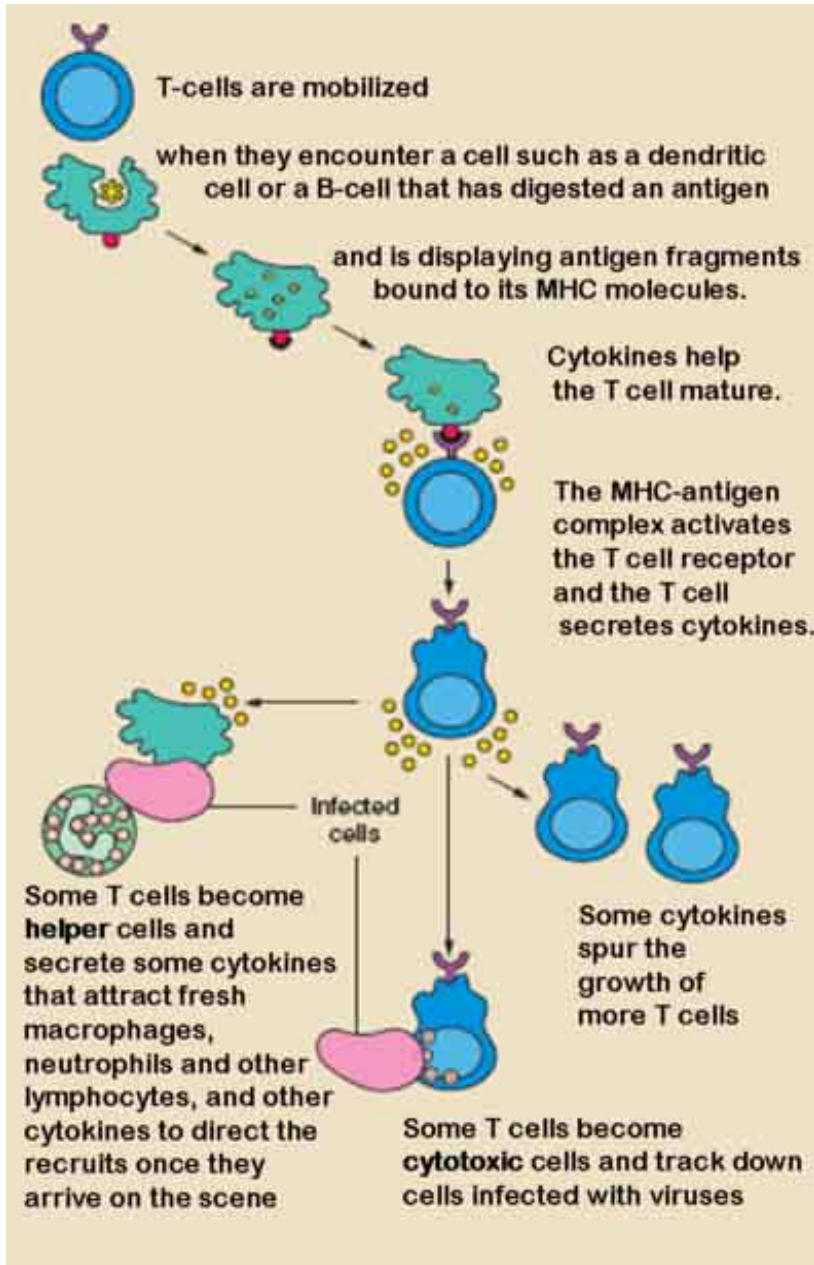


Third Line of Defense: Cell-mediated Immune Response

T Cell Receptors (TCRs)

- Molecules found on surface of T lymphocytes that recognize antigens bound to major histocompatibility complex (MHC) molecules.
- Interaction of the TCR with antigen and MHC molecules results in activation of the T lymphocyte.
- The T-cell releases cytokines. The cell reproduces and differentiates into T cells (T_C) and T cells (T_H)





Cytotoxic T Cells (T_C Cells)

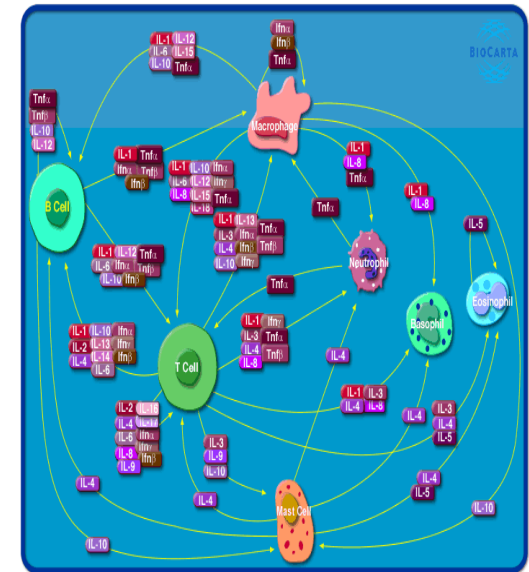
- Also called Killer T cells.
- Involved in **cell mediated immune response**.
- Directly kill cells of the body that are abnormal or infected with viruses and other intracellular pathogens.

Helper T Cells (T_H cells)

- Function to “help” regulate the activities of B cells and T_C cells during an immune response.
- Secrete various protein messengers, called **cytokines**, that determine which immune response will be activated.

Cytokines

- Regulatory proteins that act as intracellular signals and are released by certain cells in your body.
- B cells and Cytotoxic T cells do not respond to antigens unless first signaled by cytokines.
- Cytokines include:
 - **interleukins** (ILs): ‘inter’ = between & ‘leukin’ = leukocytes. Signal among leukocytes.
 - **interferons** (IFNs): Antiviral proteins.
 - **growth factors**: Stimulate stem cells to divide.
 - **tumor necrosis factors** (TNFs): Macrophages and T cells secrete TNFs to kill tumor cells and regulate immune responses.
 - **chemokines**: Signal leukocytes to rush to the site of inflammation or infection, and activate other leukocytes.

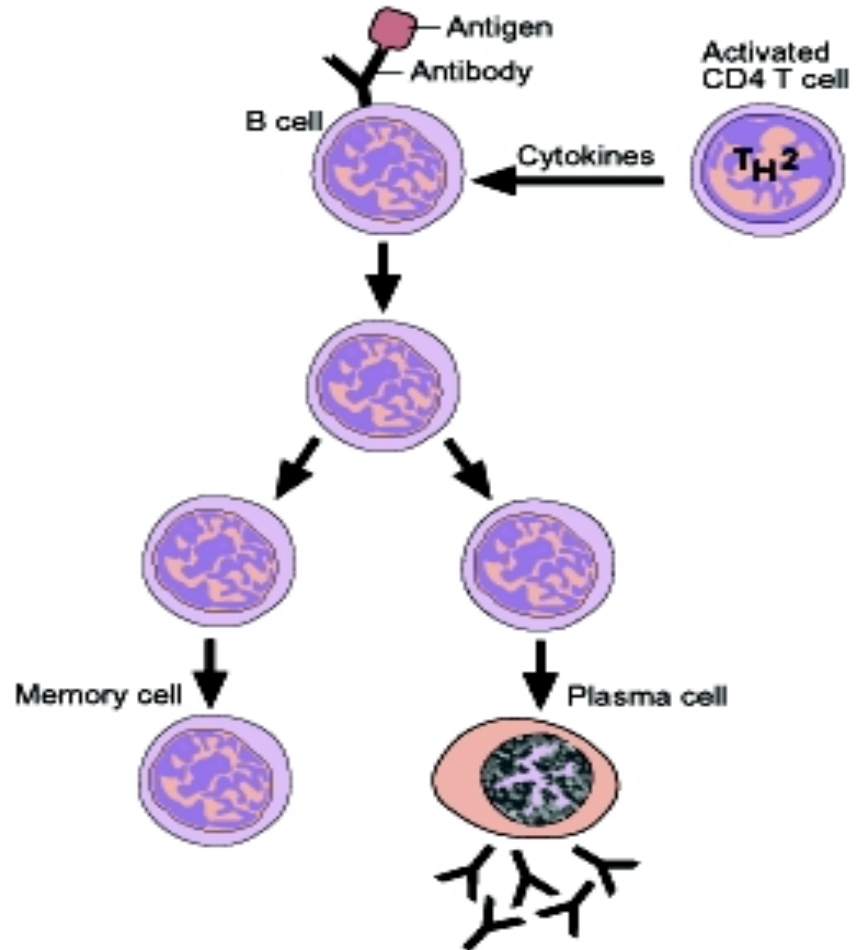


B Lymphocytes (B cells) & the Humoral Immune Response

Activation Phase &
Effector Phase

Activated B-lymphocytes
produce either:

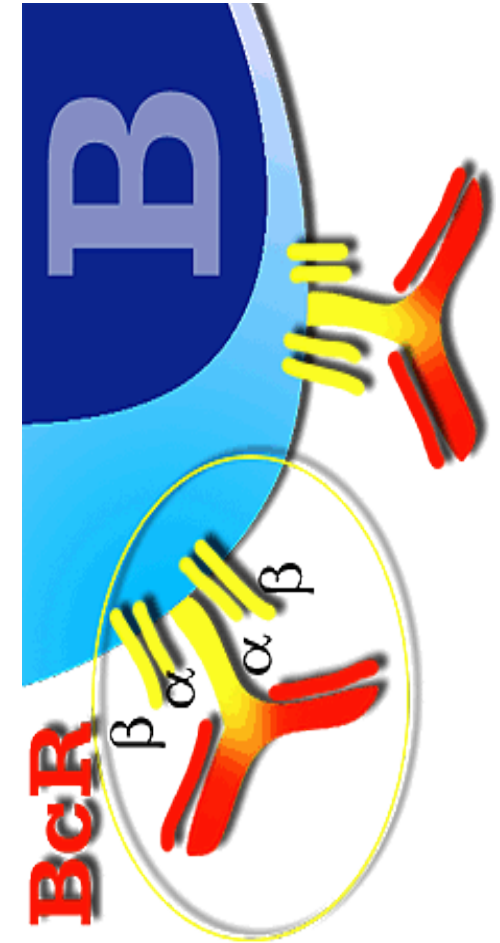
- **Plasma cells** make antibodies to a pathogen.
- **memory cells** remember the same pathogen for faster antibody production in future infections.



Third Line of Defense: Humoral Immune Response

Antigen Presentation & B Cell Receptors (BCRs)

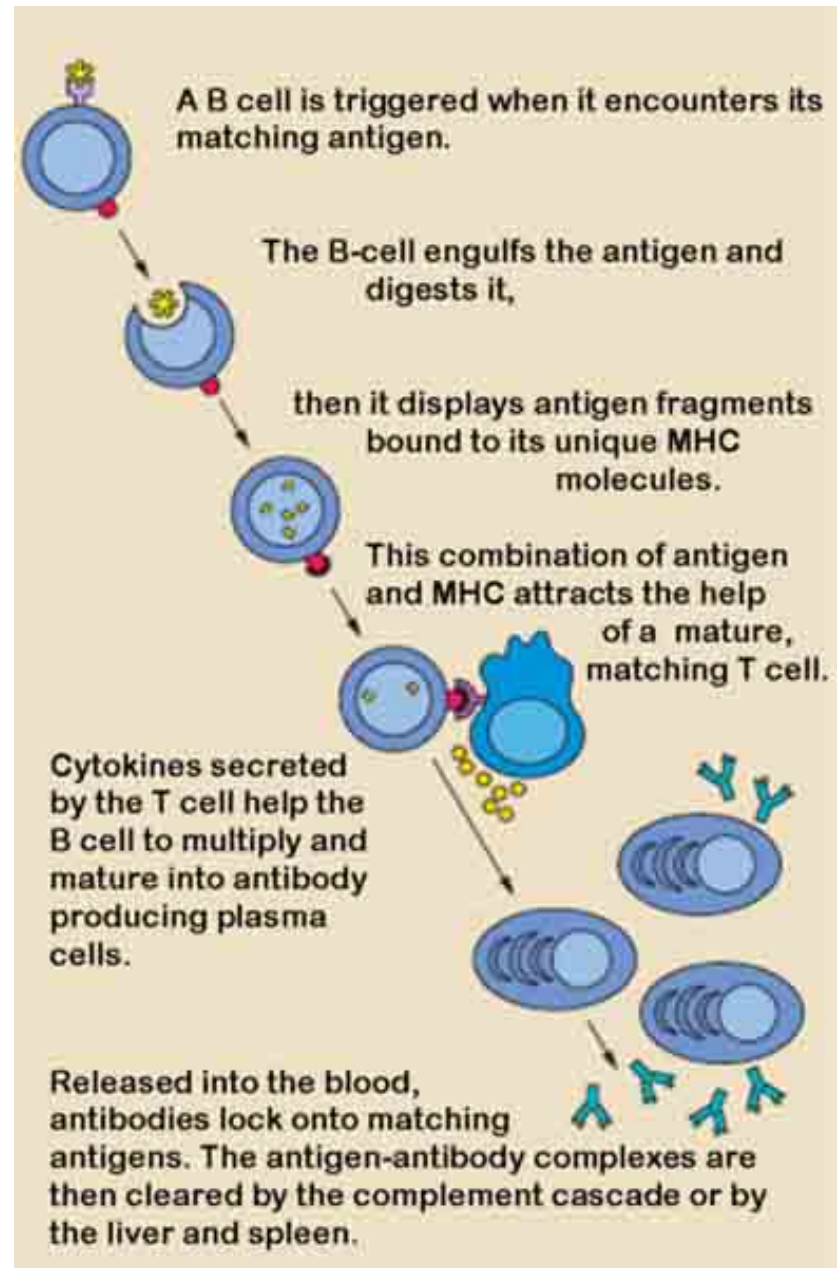
- Some antibodies are secreted by **plasma cells**, others are attached to B cell membranes.
- If attached to the B cell membrane, the antibody is called a **B-cell receptor**.
- Surface of each -cell is covered by ~ 500,000 identical B cell receptors.
- Each BCR complements a specific **antigenic determinant** that the body may or may not ever encounter (ex. rattlesnake venom proteins).
- Your body has billions of B cells, each with BCRs for a different antigenic determinant.
- **Q:** *How are B cells turned on to begin producing memory cells and plasma cells?*



Humoral Immune Response

Steps of the humoral immune response include:

- **Antigen presentation:** Antigen presenting cells encounter compatible T_H cells that have receptors for those same antigenic determinants.
- **Helpers multiply:** Those T_H cells proliferate and bind to B cells.
- **B cells activated:** Activated T_H cell secretes interleukin, activating the B cell so that it quickly multiplies and differentiates.
- **Antibodies produced:** Plasma B cells rapidly produce large numbers of antibodies. This high level of activity means that these cells are short-lived.
- **Memory B cells** can survive for years, ready to initiate antibody production of that particular antigen is encountered again.



Confused?



Here are links to fun resources that further explain acquired immunity:

- [Acquired Immunity Main Page](#) on the Virtual Cell Biology Classroom of [Science Prof Online](#).
- [Immune System](#) animation and quiz by McGraw-Hill
- [Cellular Immune Response](#) narrated animation and quiz from W. H. Freeman.
- [Humoral Immune Response](#) narrated animation and quiz from W. H. Freeman.
- [Phagocytosis](#) animation and quiz by McGraw-Hill.
- [Immune System](#) “Who Wants to Be a Millionaire” game.
- [“Assassin”](#) song by John Mayer
- [Immune System Defender](#), online game from the Nobel Prize website. Use your force of white blood cells to destroy invading bacteria, before they overpopulate and cause disease.
- [Immune System Game](#), a collection of online fun and educational games about immunology.

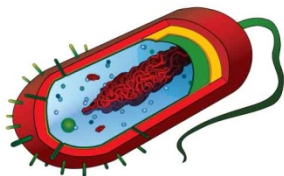
Are microbes intimidating you?



Do yourself a favor. Use the...

Virtual Microbiology Classroom (VMC) !

The VMC is full of resources to help you succeed,
including:



- practice test questions
- review questions
- study guides and learning objectives

You can access the VMC by going to the Science Prof Online website

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