



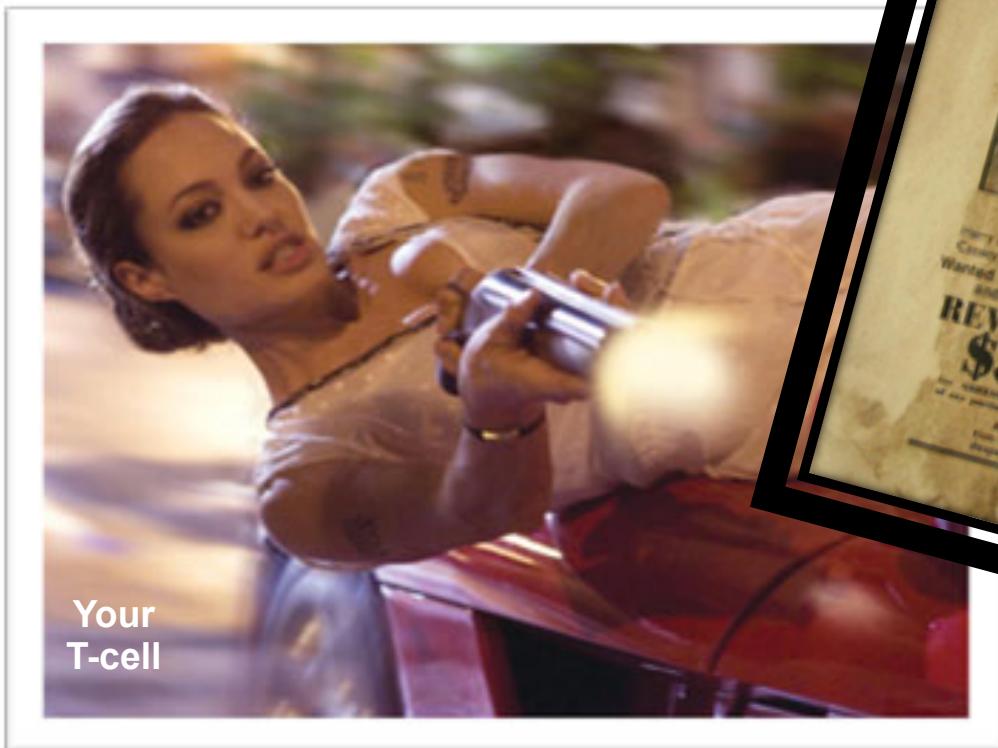
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# Immune System II: Acquired Immunity



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



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

## INNATE

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

Physical: 1. \_\_\_\_\_  
2. \_\_\_\_\_

Chemical: 1. \_\_\_\_\_  
2. \_\_\_\_\_

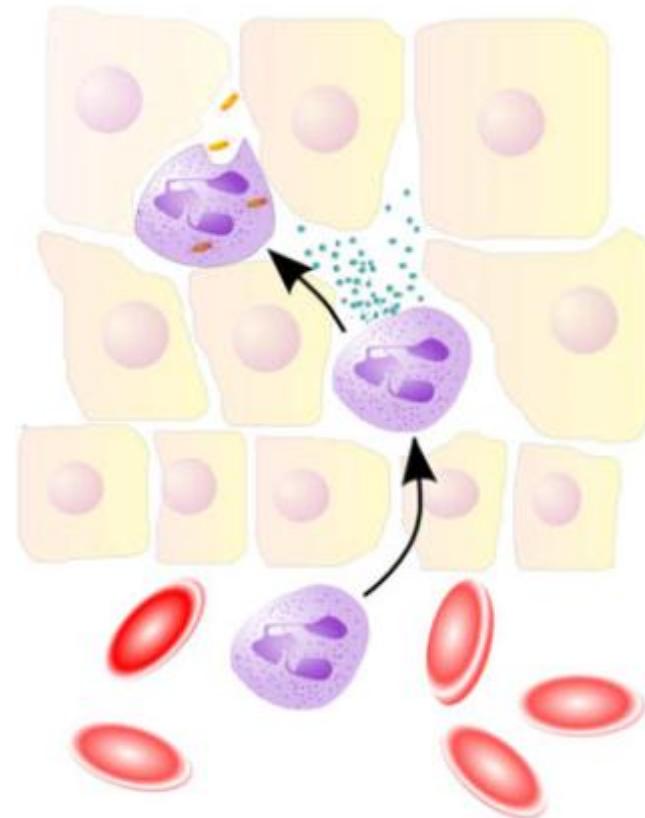




## RECAP

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

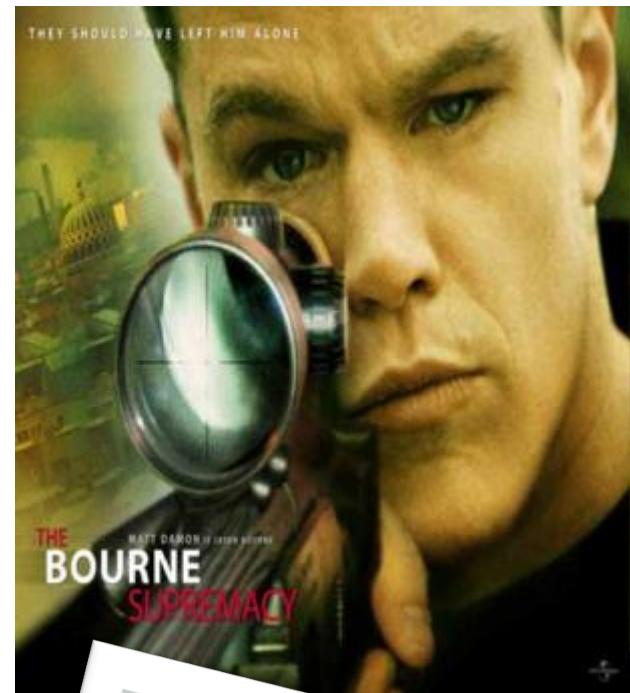
- In play when pathogens penetrate the skin or mucous membranes.
- Composed of cells, antimicrobial chemicals, and processes but **no physical barriers**.
- Many of these components are contained or originate in the blood.
- Includes:
  1. Leukocytes involved in nonspecific immune defense usually do 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?



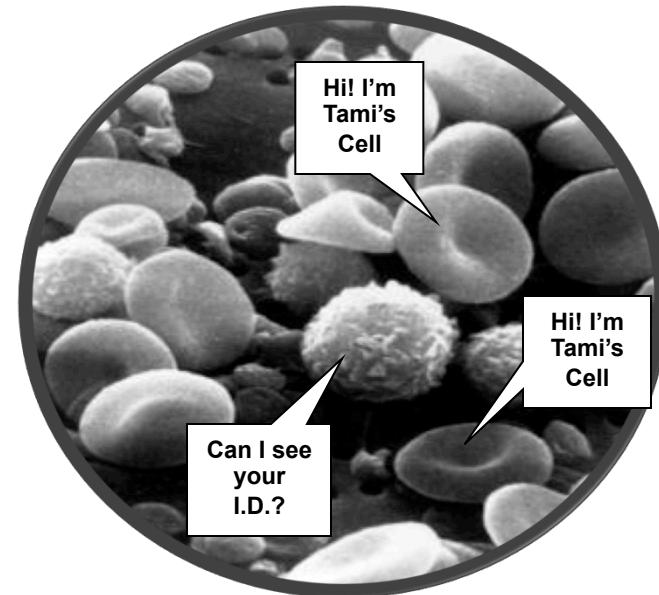
# Antigens

- 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



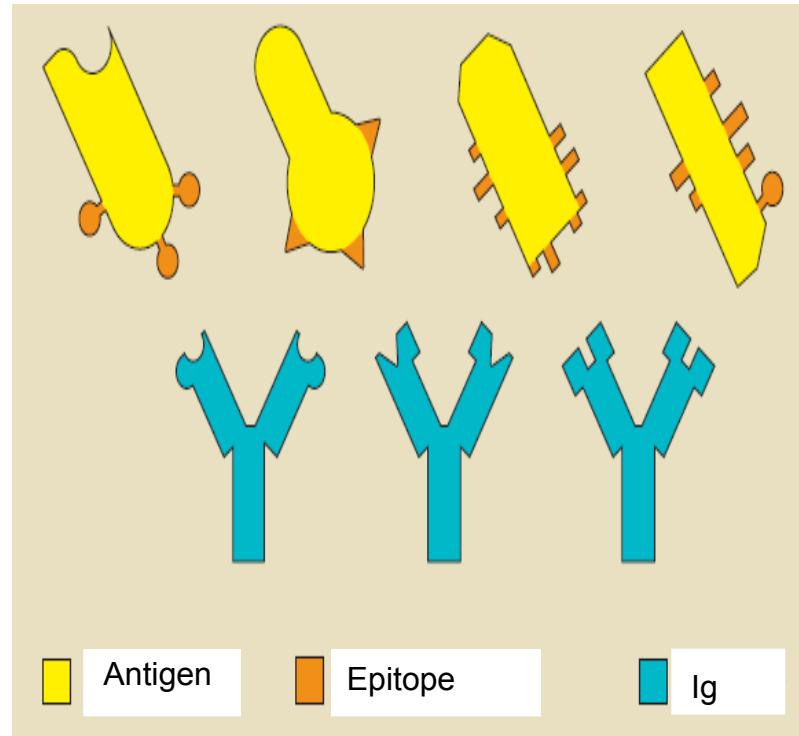
## Antigens Are Like Name Tags

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.



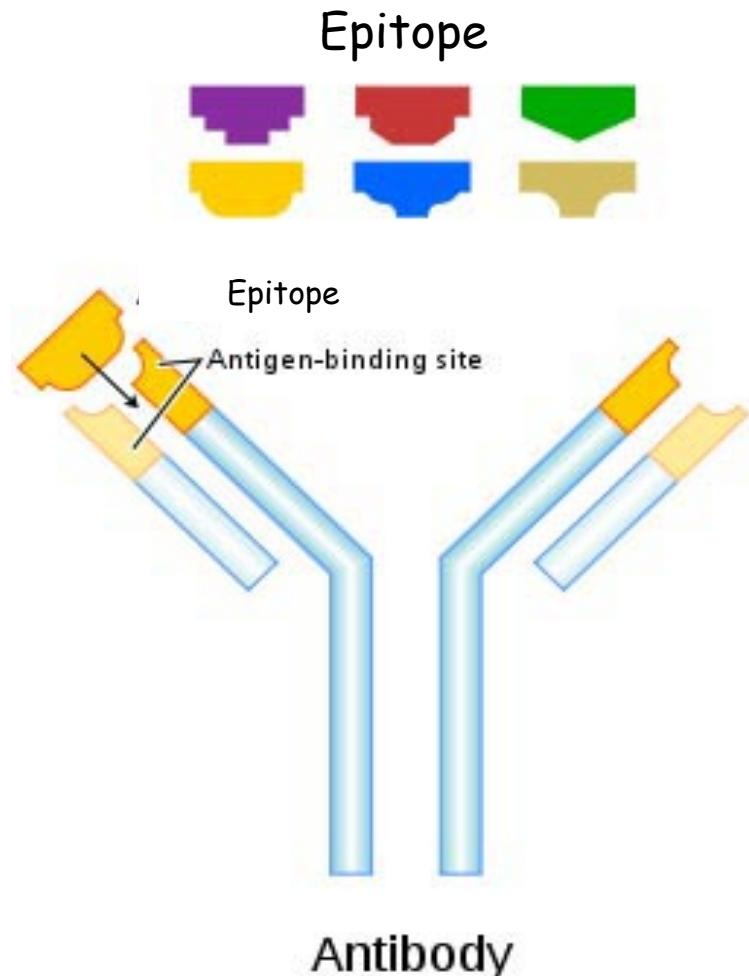
# Antigens

- 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

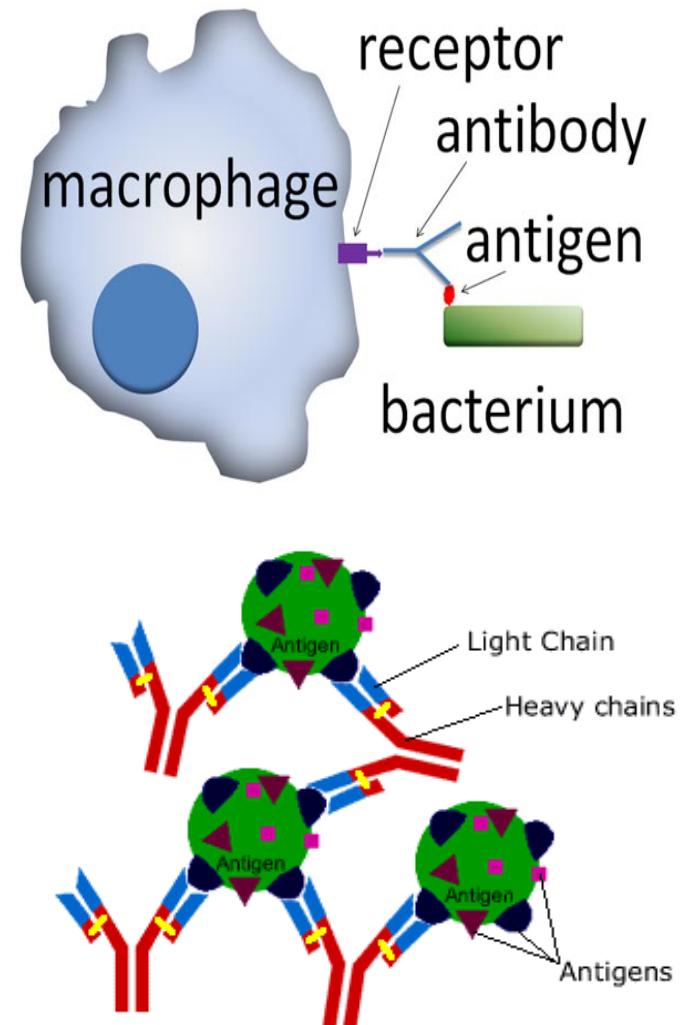
- Also called immunoglobulins (Ig).
- Proteinaceous molecules that bind antigenic determinants at the antigen-binding site.



# How Antibodies Work

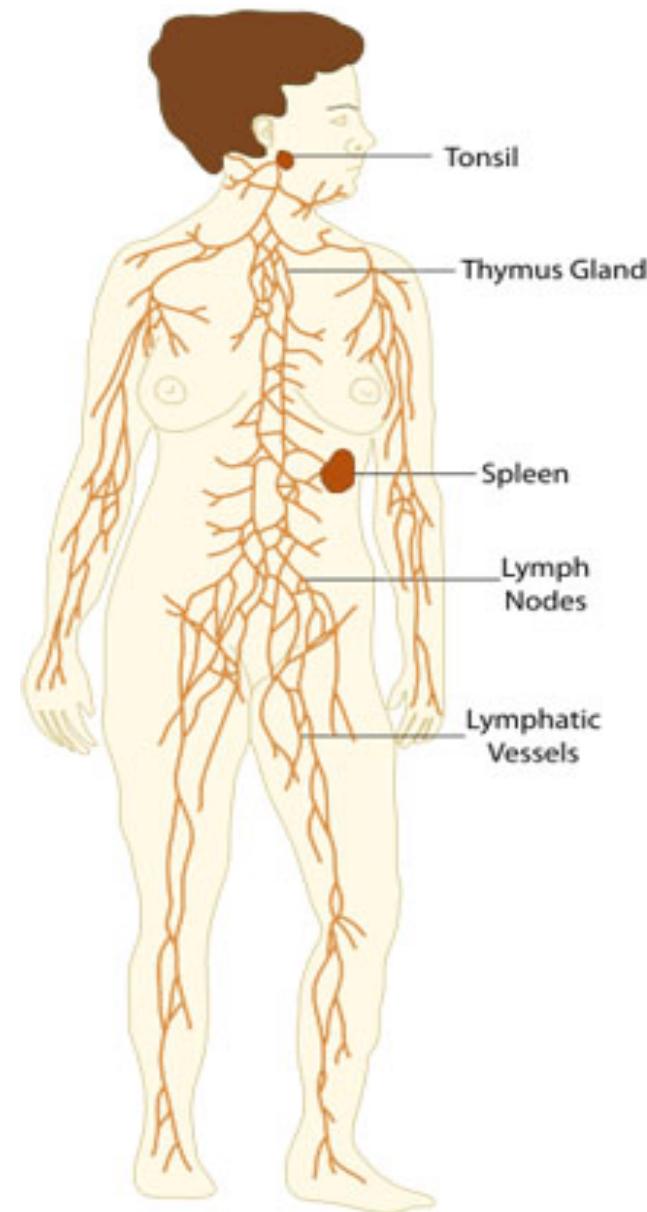
- Some act as **opsonins**, markers to identify antigens for phagocytes and stimulate phagocytosis.
- Some work as **antitoxins** (i.e. they neutralize toxins for e.g. those causing diphtheria and tetanus).
- Some attach to bacterial flagella making them less active and easier for phagocytes to engulf.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



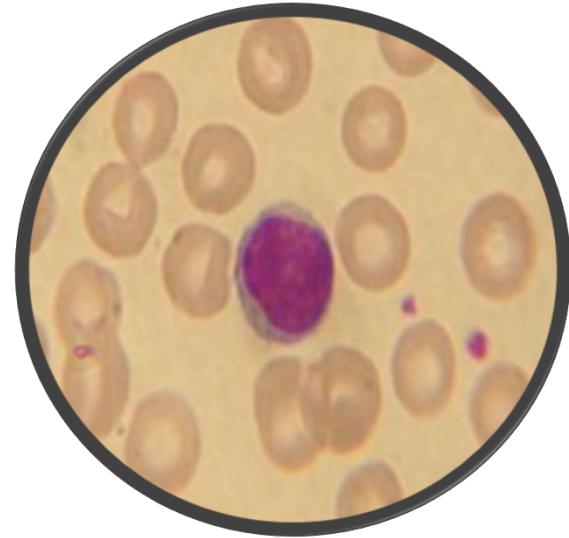


# Lymphocytes

- 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**.

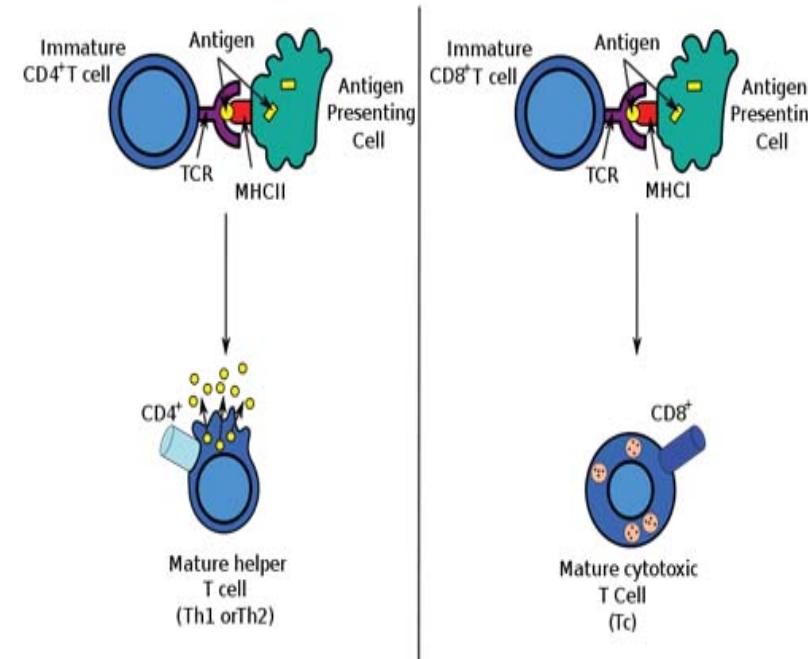


# What Is an Antigen Presenting Cell?

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

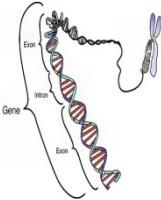
The larger the force, the more likely one of the officers will run into a “bad guy” and so that the body will be able to apprehend it.

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).



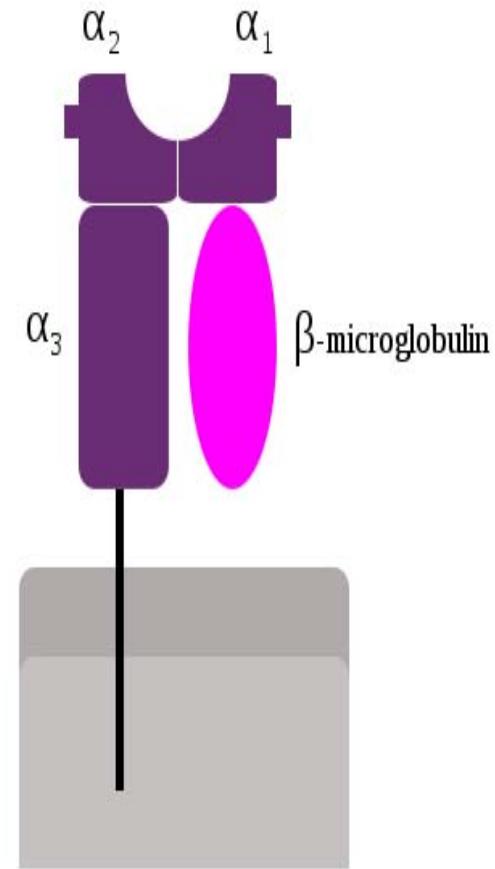
Any WBC that can grab and present an antigen to another, is called an **Antigen Presenting Cell (APC)**.

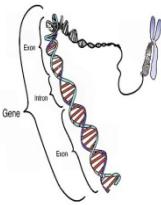
APCs include **B cells, macrophages and dendritic cells**.



# Major Histocompatibility Complex (MHC)

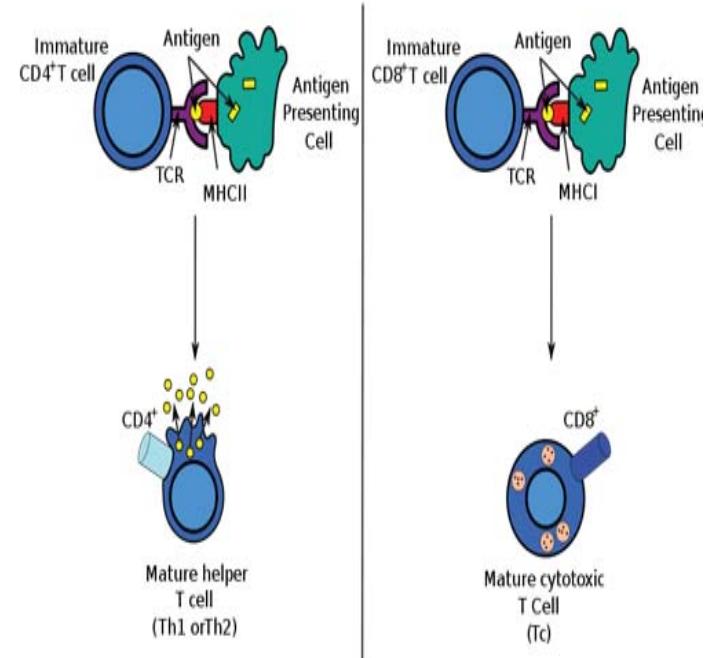
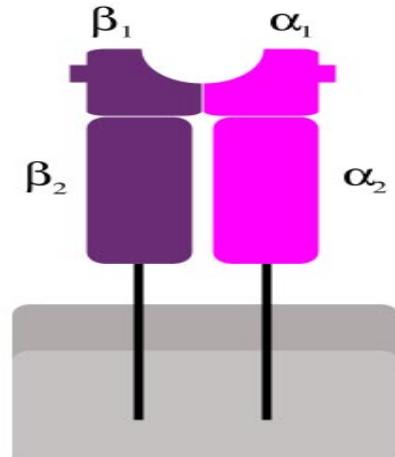
- Collection of **genes** on chromosome 6, which code for major histocompatibility **glycoproteins**.
- **MHC1** proteins are in the plasma membrane of all your nucleated cells (non-professional APCs).
- Since every human (other than identical twins) is genetically unique, MHC1 proteins differ between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





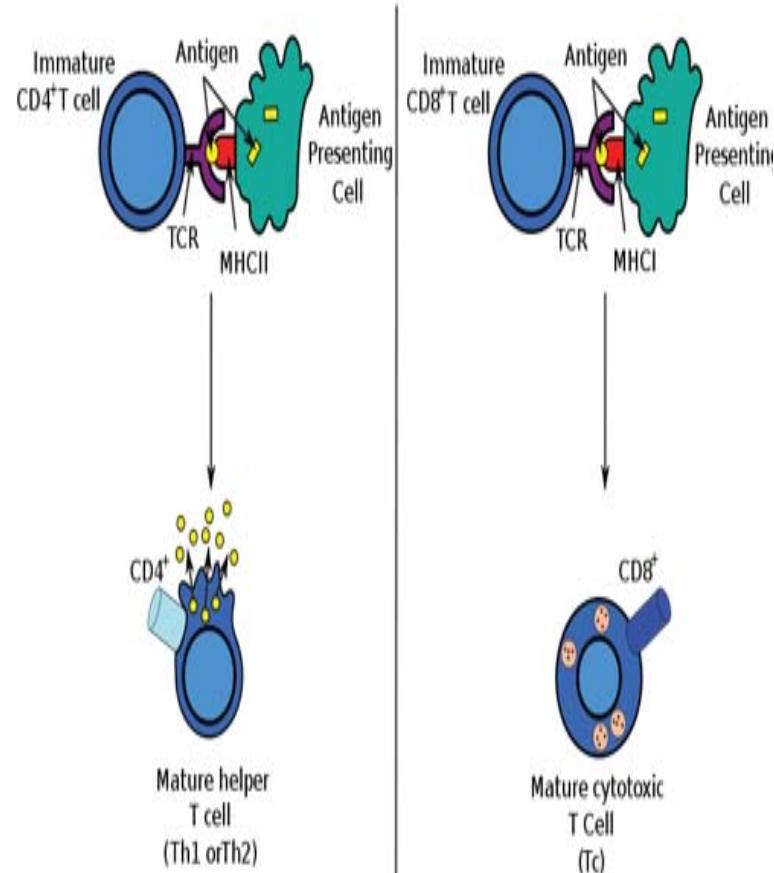
# Major Histocompatibility Complex (MHC)

- MHC<sup>2</sup> 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.



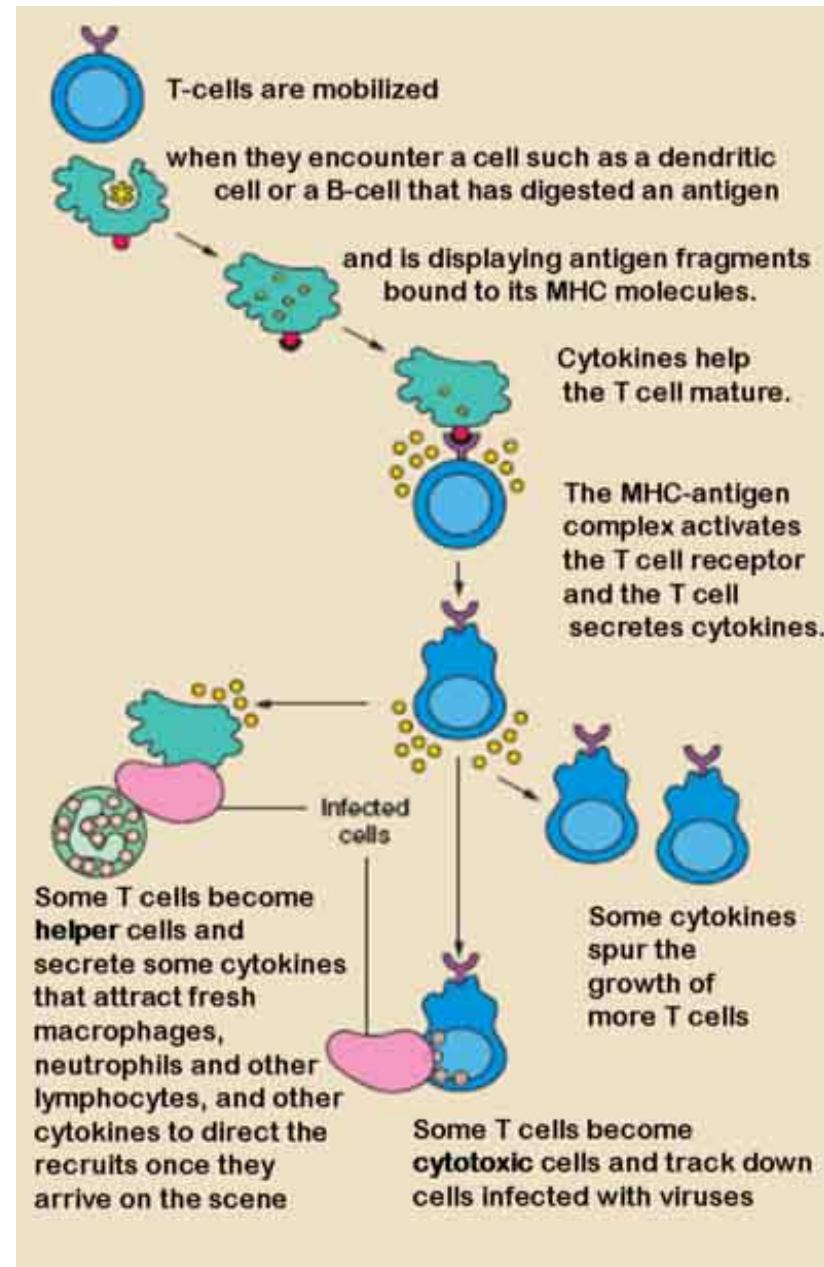
# T Lymphocytes (T cells) & the Cellular Immune Response

- 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



# 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 differentiate into T cells ( $T_C$ ) and T cells ( $T_H$ )

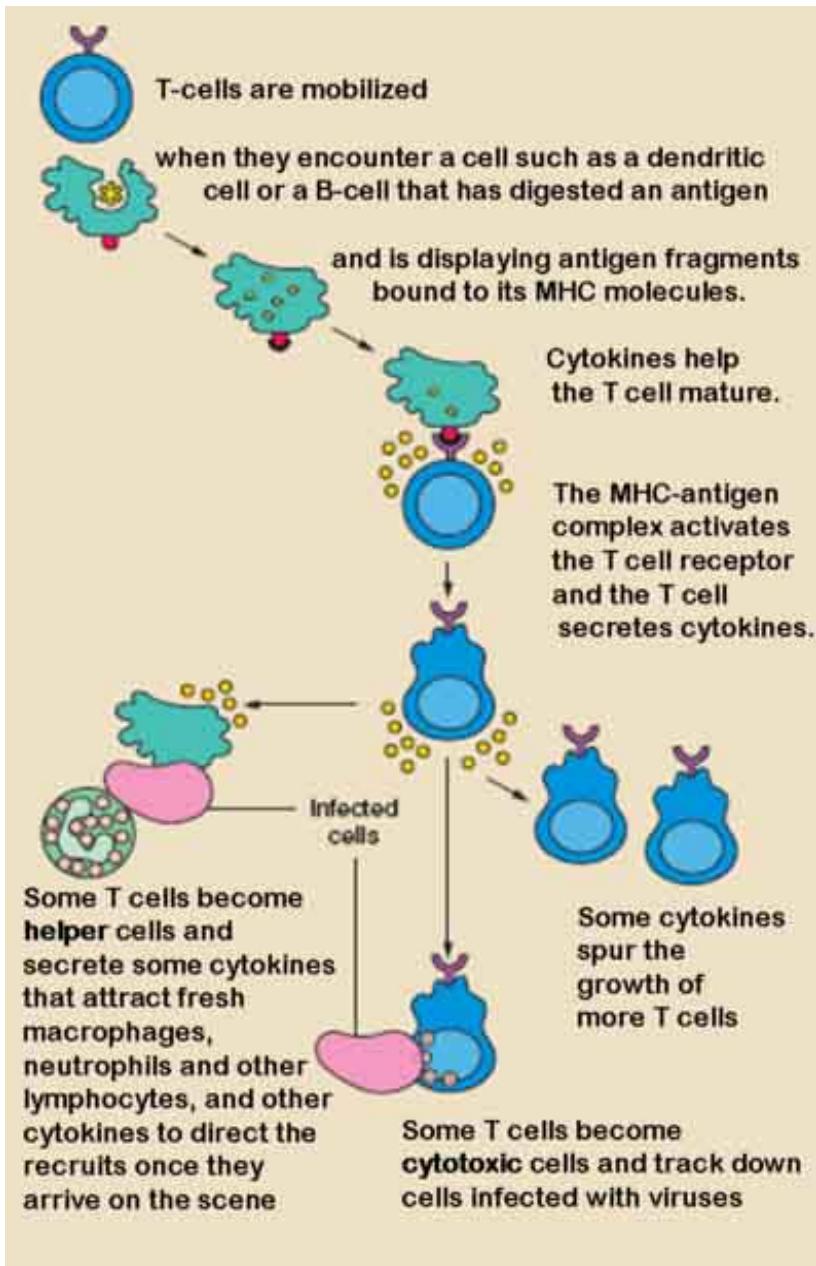


## Cytotoxic T Cells ( $T_c$ Cells)

- 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.

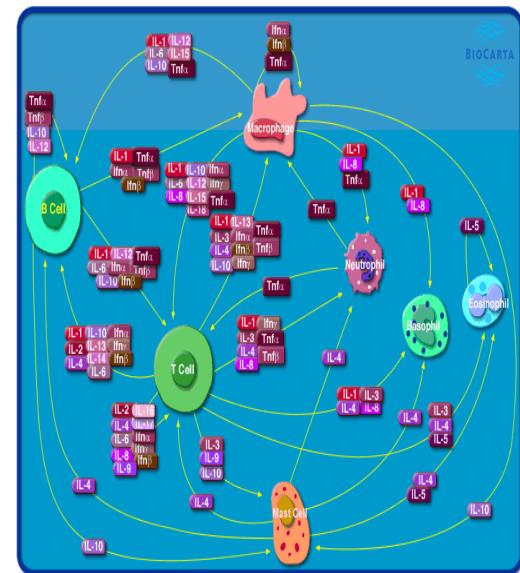
## Helper T Cells ( $T_h$ cells)

- 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.

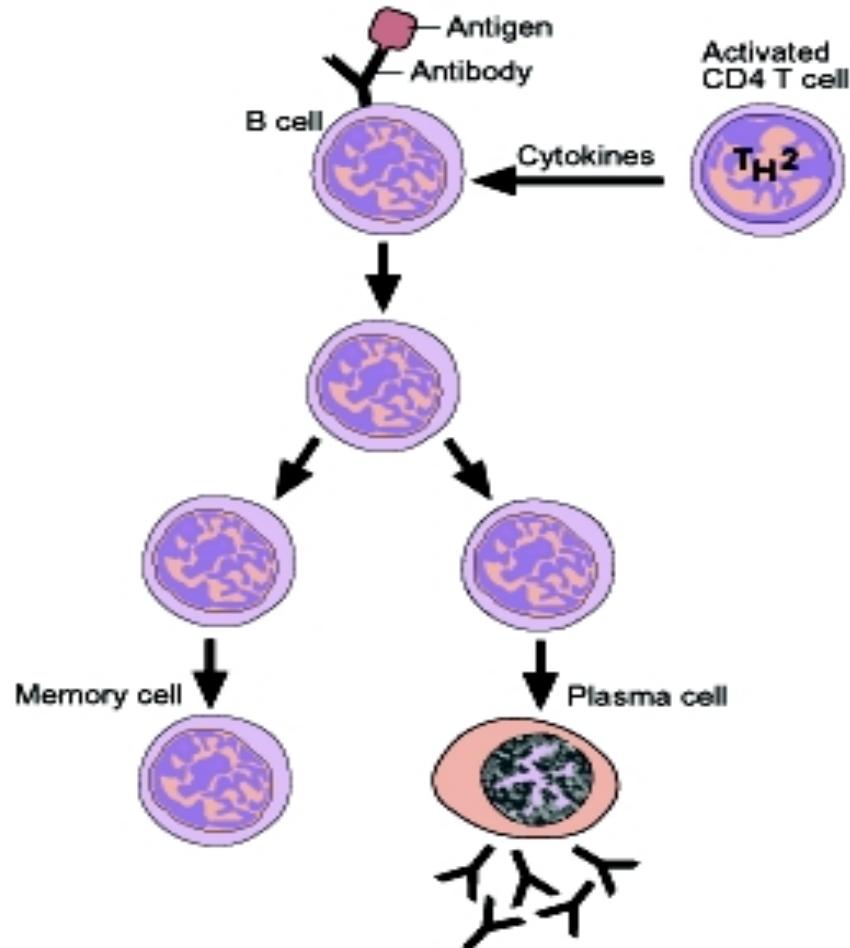


# B Lymphocytes (B cells) & the Humoral Immune Response

Activation Phase &  
Effector Phase

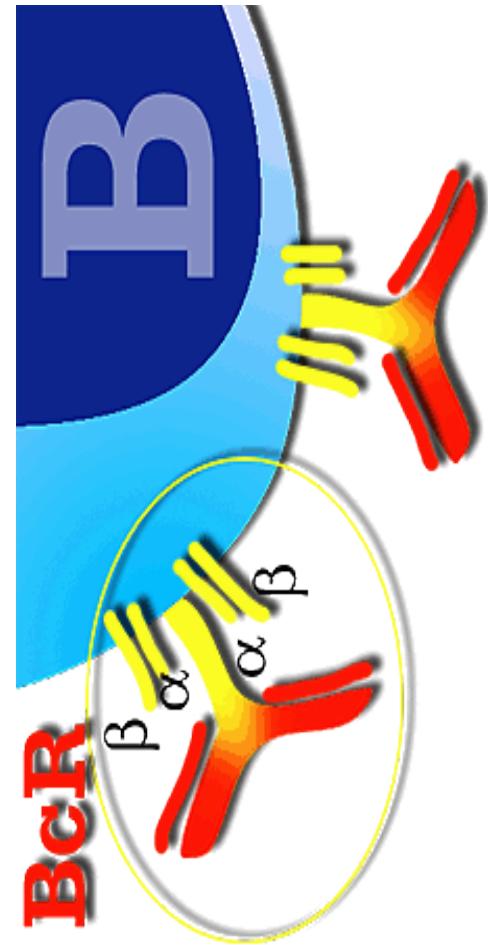
Activated B-lymphocytes  
produce either:

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



# Antigen Presentation & B Cell Receptors (BCRs)

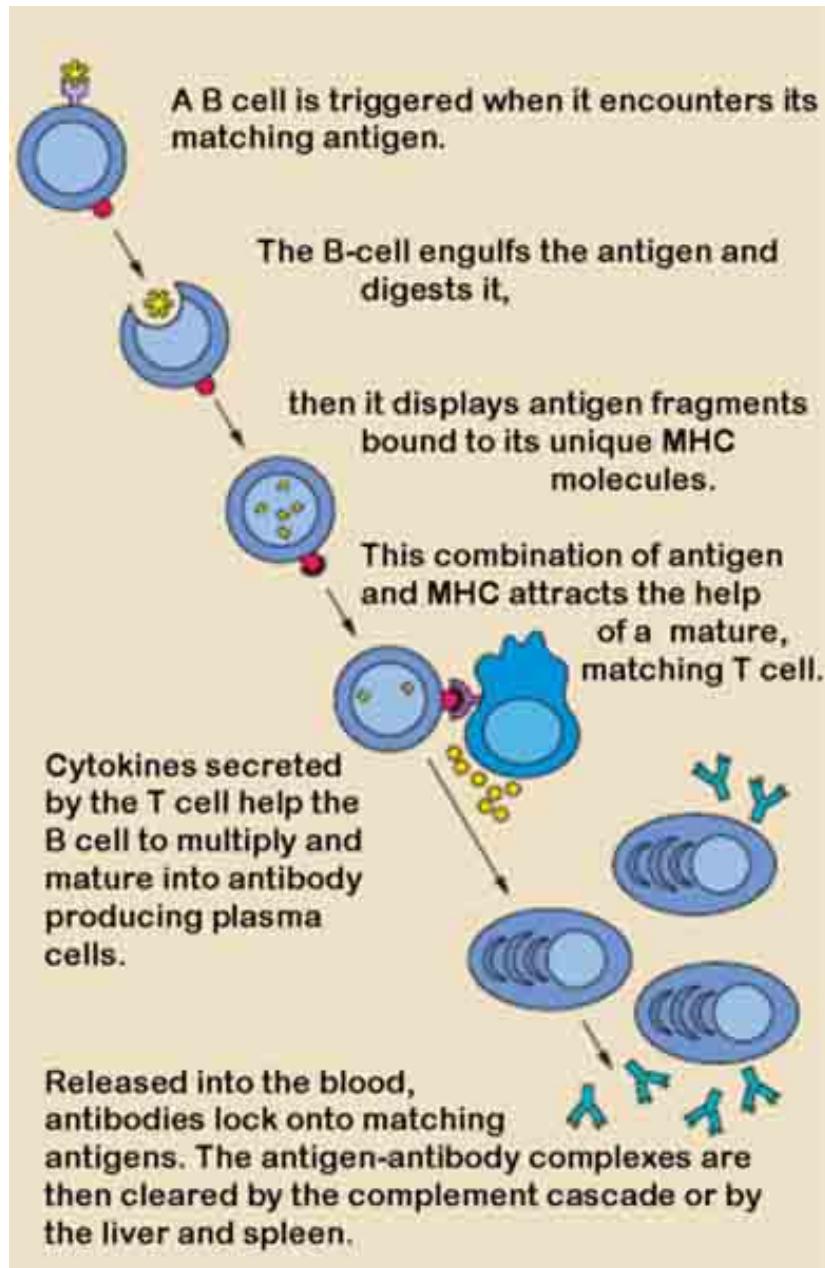
- Some antibodies are secreted by **plasma cells**, others are attached to B cell membranes.
- If attached to the B cell membrane, the antibody is called a **B-cell receptor**.
- Surface of each -cell is covered by ~ 500,000 identical B cell receptors.
- Each BCR is complements a specific **antigenic 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 if 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.

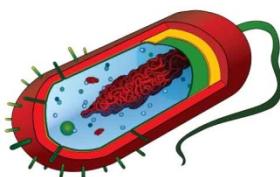


# Are microbes intimidating you?

*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  
[www.ScienceProfOnline.com](http://www.ScienceProfOnline.com)