# Adaptive Immunity: Specific Defenses of the Host

- Innate immunity:
- Adaptive (_____) immunity: Specific antibody and lymphocyte response to an antigen.

## Terminology

- Antigen (___): A substance that causes the body to produce specific antibodies or sensitized T cells.
- Antibody (___): Proteins made in response to an An; can combine with that An.
- Complement: Serum proteins that bind to Ab in an An–Ab reaction; cause cell lysis.

## Dual Nature of Adaptive Immunity

- Adaptive immunity develops during an individual's lifetime. In other words, it is acquired.
-
- mediated by complex interaction of antibodies, lymphocytes and macrophages

- Humoral immunity involves antibodies produced by B cells.
  - B cells recognize antigens by antibodies on their surfaces.

- Cell-mediated immunity involved T cells.
  - T cells recognize antigens by TCRs (_____) on their surfaces.

## Terminology

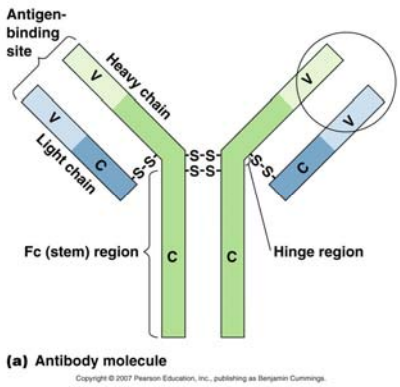
- Serology: The study of reactions between antibodies and antigens.
- Antiserum: The generic term for serum because it contains Ab.
- Globulins:
- Immunoglobulins:
- Gamma ($\gamma$) globulin: Serum fraction containing Ab.
- Antigen (An) - foreign substance that elicits immune response

## Antigens

- proteins and polysaccharides most antigenic, lipids and nucleic acid less antigenic
- - usually >1000 molecular weight required for immunogenicity (antigenicity)
- - specificity on antigen =
- - hapten = small compound not antigenic by itself but when coupled to larger molecule becomes antigenic
- - ex. penicillin + serum proteins =
- - ex. poison ivy - urusiol oil = hapten; + tissue proteins =

## Antigenic Determinants

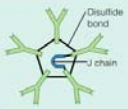
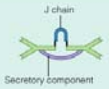
- Antibodies recognize and react with antigenic determinants or epitopes on an antigen.




## Antibody Structure

## Five Classes of Antibodies

**TABLE 17.1 A Summary of Immunoglobulin Classes**

| Characteristics | IgG | IgM | IgA | IgD | IgE |
|---|---|---|---|---|---|
| |  |   |   |  |  |
| **Structure** | Monomer | Pentamer | Dimer (with secretory component) | Monomer | Monomer |
| **Percentage of total serum antibody** | 80% | 5–10% | 10–15%* | 0.2% | 0.002% |
| **Location** | Blood, lymph, intestine | Blood, lymph, B cell surface (as monomer) | Secretions (tears, saliva, mucus, intestine, milk), blood, lymph | B cell surface, blood, lymph | Bound to mast and basophil cells throughout body, blood |
| **Molecular weight** | 150,000 | 970,000 | 405,000 | 175,000 | 190,000 |
| **Half-life in serum** | 23 days | 5 days | 6 days | 3 days | 2 days |
| **Complement fixation** | Yes | Yes | No† | No | No |
| **Placental transfer** | Yes | No | No | No | No |
| **Known functions** | Enhances phagocytosis; neutralizes toxins and viruses; protects fetus and newborn | Especially effective against microorganisms and agglutinating antigens; first antibodies produced in response to initial infection | Localized protection on mucosal surfaces | Serum function not known; presence on B cells functions in initiation of immune response | Allergic reactions; possibly lysis of parasitic worms |

*Percentage in serum only; if mucous membranes and body secretions are included, percentage is much higher.
† May be yes via alternate pathway.



### IgG antibodies

- _____
- Majority of serum antibodies
- Fix complement
-

### IgM Antibodies

- _____
- _____
- Agglutinates microbes; first Ab produced in response to infection

### IgA Antibodies

-
- In secretions
- Mucosal protection

### IgD Antibodies

-
- In blood, lymph, and on B cells
- On B cells, initiate immune response

**IgE Antibodies**

- 
- On mast cells, basophils, and in blood
- Allergic reactions; lysis of parasitic worms

**Mechanisms of Ab Action**

- neutralization - Abs bind to toxins before they exert toxic effect; bind to viruses preventing attachment
- - antitoxin =
  - - antivenin (_____) - specific to snake venom, spider venom etc. – can use only once Why?
- agglutination - bacteria and other foreign particles clumped together for more efficient phagocytosis; clumping of bacteria retards their spread

- precipitation - small soluble proteins ppt, more easily phagocytized
- opsonization - coating of antigen with Abs enhances phagocytosis

- complement fixation - binding of IgG, IgM to foreign cell activates complement cascade
- complement cascade - complex series of reactions causing soluble serum proteins to sequentially bind to antigen-antibody complexes on target cells
- - complement proteins form hollow tubes in target cell membranes $\rightarrow$ _____
- - more effective against gram (-), less effective against gram (+) Why?

- Whatever the mechanism, the binding of Ab to antigen (An-Ab complex) facilitates the destruction of the antigen

**Activation of B Lymphocytes**

For every potential antigen there exists a B cell that can produce an Ab specific to it.

**The Diversity of Antibodies**

- During embryonic development, regions of V genes combine with C genes to produce $> 10^{15}$ different antibodies.

**Clonal Selection**

- exposure to antigen stimulates B cell proliferation and differentiation into plasma cells + memory cells
- 
- memory cells produce Abs next time antigen present

**Activation of B Cells**

- T-independent antigen - antigen alone stimulates B cell proliferation
- T-dependent antigen - most of time antigen presenting cell (_____) required

**T-Dependent Antigens**

- APC = macrophage (also dendritic cells, even B-cells)
- antigen presented along with MHC to T helper cells
- macrophage secretes interleukins (_____)
- - IL-1 $\rightarrow$ T helper proliferation $\rightarrow$ IL-2 $\rightarrow$ activated B cell proliferation

(See diagram on last page)

**Antigen-Presenting Cells**

- 
- An fragments on APC surface with MHC
  - B cells (  )
  - Dendritic Cells (  )
  - Macrophages (  )

- Activated macrophages: Macrophages stimulated by ingesting An or by cytokines (_____).

**How long does it take humoral immunity to work?**

- 1° (_____) response, typically 7-10 days, IgMs first then IgG
- 2° (_____) response, typically 1-3 days, mostly IgG from memory cells

**Self-Tolerance**

- 
- Clonal deletion
  - The process of destroying B and T cells that react to self antigens.

**Antigen—Antibody Binding**

- Affinity: Strength of bond between Ab and An.
- Specificity:

**T Lymphocytes**
**T Cells**

- Helper T Cells (CD4, $T_H$)
  - $T_H1$: Activate cells related to cell-mediated immunity
  - $T_H2$: Activate B cells to produce eosinophils, IgM, and IgE.

- Cytotoxic T Cells (CD8, $T_C$) activated in cytotoxic T lymphocytes.
  - CTLs recognize An + MHC I.
  - 

- Regulatory T Cells ($T_R$)
  - 

**TABLE 17.2 Principal Cells That Function in Cell-Mediated Immunity**

| Cell | Function |
|---|---|
| **Helper T ($T_H1$) cell** | Activates cells related to cell-mediated immunity: macrophages, CD8 T cells, and natural killer cells |
| **Helper T ($T_H2$) cell** | Stimulates production of eosinophils, IgM, and IgE |
| **Cytotoxic T lymphocyte (CTL)** | Destroys target cells on contact |
| **Regulatory T ($T_R$) cell** | Regulates immune response and helps maintain tolerance |
| **Activated macrophage** | Enhanced phagocytic activity; attacks cancer cells |
| **Natural killer (NK) cell** | Attacks and destroys target cells; participates in antibody-dependent cell-mediated cytotoxicity |



**Extracellular Killing**

- Antibody-dependent cells-mediated cytotoxicity.
- Natural killer cells destroy cells which don't express MHC I.

**Active and Passive Immunity**

- active - Ab production after exposure to antigen
- - long term protection
- - natural - i
- - artificial -
- - neutralized toxin
- - exotoxin - ex. diphtheria, tetanus

- passive - receive foreign Abs
- -
- - natural - mother → fetus across placenta; _____
- - artificial - Abs produced in another animal (ex. horse), purified
- - Abs to exotoxins
- - antiserum = blood serum containing specific Abs
- - antisera against snake and spider venom =

**Study Objectives**

1. Compare and contrast innate immunity with adaptive immunity.

2. Define: antigen, antibody, serology, antiserum, globulins, immunoglobulins, and gamma globulin.

3. Describe the characteristics of antigens and haptens.

4 Describe an antibody (structure, function etc.). Be able to draw a typical antibody.

5. Describe the 5 classes of antibodies.

6. Describe the 5 mechanisms of antibody action.

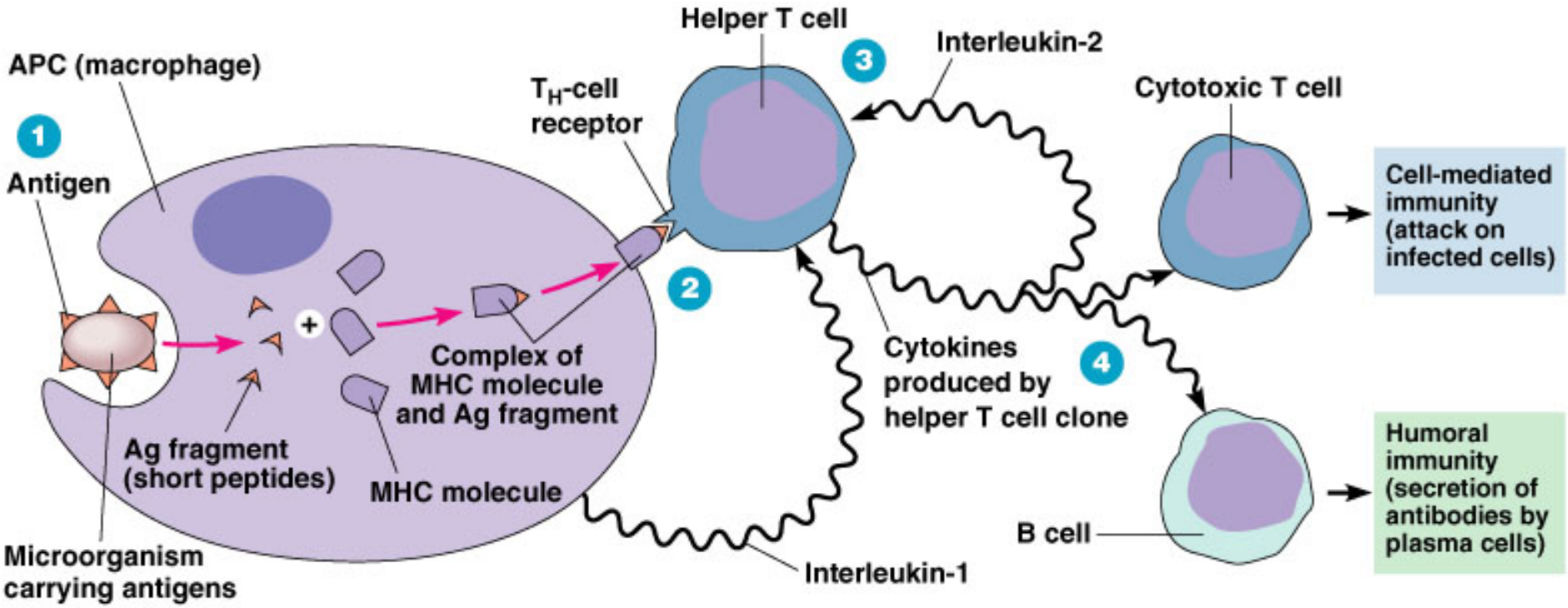
7. Describe the clonal selection of B cells.

8. Explain the importance of clonal deletion of T cells and B cells.

9. Describe the various interactions of B cells (plasma, memory), T cells (helper, cytotoxic, regulatory), APCs, macrophages, interleukins etc.

10. How long does it take humoral immunity to work?

11. Compare and contrast active and passive immunity, both natural and artificial. Give examples.




1 An antigen-presenting cell (APC) encounters and ingests a microoganism. Antigen fragments (short peptides) from the microorganism combine internally with MHC (self molecules) and the complex of MHC molecules and antigen fragments is presented on the surface of the APC.

2 A helper T ($T_H$) cell receptor binds to the complex, stimulating the APC to secrete interleukin-1.

3 This interleukin-1 stimulates the helper T cell to produce interleukin-2, which then stimulates that helper T cell to form a clone of helper T cells.

4 The cells of this clone in turn produce cytokines, stimulating cells of both immune systems.