3 [The Adaptive Immune System]
   • 17-1 Differentiate innate from adaptive immunity.
   • 17-2 Differentiate humoral from cellular immunity.

4 [Immunity]
   • Innate immunity: defenses against any pathogen
   • Adaptive immunity: induced resistance to a specific pathogen

5 [Historical Development]
   • Pasteur observed immunity in chickens injected with weakened pathogens
   • Von Behring received the Nobel prize for development of antitoxin
   • Ehrlich’s work led to the identification of antibodies in serum

6

7 [Dual Nature of Adaptive Immunity]
   • T and B cells develop from stem cells in red bone marrow

8

9 [Dual Nature of Adaptive Immunity]
   • Humoral immunity
     • Due to antibodies
     • B cells mature in the bone marrow
       • Chickens: bursa of Fabricius

10 [Dual Nature of Adaptive Immunity]
   • Cellular immunity
     • Due to T cells
     • T cells mature in the thymus

11
   • Is vaccination an example of innate or adaptive immunity? 17-1
   • How was basic research on chicken diseases related to the discoveries of both humoral and cellular immunity? 17-2

12 [Antigens and Antibodies]
   • 17-3 Define antigen, epitope, and hapten.
   • 17-4 Explain the function of antibodies, and describe their structural and chemical characteristics.
   • 17-5 Name one function for each of the five classes of antibodies.
   •
**The Nature of Antigens**

- Antigen (Ag): a substance that causes the body to produce specific antibodies or sensitized T cells
  - Antibodies (Ab) interact with epitopes, or antigenic determinants
  - Hapten: antigen is combined with carrier molecules

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**The Nature of Antibodies**

- Globular proteins called immunoglobulins
  - The number of antigen-binding sites determines valence

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**IgG Antibodies**

- Monomer
  - 80% of serum antibodies
  - Fix complement
  - In blood, lymph, and intestine
  - Cross placenta
  - Enhance phagocytosis; neutralize toxins and viruses; protect fetus and newborn
  - Half-life = 23 days

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**IgM Antibodies**

- Pentamer
  - 5–10% of serum antibodies
  - Fix complement
  - In blood, in lymph, and on B cells
  - Agglutinate microbes; first Ab produced in response to infection
  - Half-life = 5 days

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**IgA Antibodies**

- Dimer
  - 10–15% of serum antibodies
  - In secretions
  - Mucosal protection
  - Half-life = 6 days
25 **IgD Antibodies**
- Monomer
- 0.2% of serum antibodies
- In blood, in lymph, and on B cells
- On B cells, initiate immune response
- Half-life = 3 days

26 **IgE Antibodies**
- Monomer
- 0.002% of serum antibodies
- On mast cells, on basophils, and in blood
- Allergic reactions; lysis of parasitic worms
- Half-life = 2 days

27
- Does an antibody react with a bacterium as an antigen or as an epitope? 17-3
- The original theoretical concepts of an antibody called for a rod with antigenic determinants at each end. What is the primary advantage of the Y-shaped structure that eventually emerged? 17-4
- Which class of antibody is most likely to protect you from a common cold? 17-5

28 **B Cells and Humoral Immunity**
- 17-6 Compare and contrast T-dependent and T-independent antigens.
- 17-7 Differentiate plasma cell from memory cell.
- 17-8 Describe clonal selection.
- 17-9 Describe how a human can produce different antibodies.
- 17-10 Describe four outcomes of an antigen–antibody reaction.

29 **Activation of B Cells**
- Major histocompatibility complex (MHC) expressed on mammalian cells
- T-dependent antigens
  - Ag presented with (self) MHC to TH cell
  - TH cell produces cytokines that activate the B cell
- T-independent antigens
  - Stimulate the B cell to make Abs

30

31

32 **Clonal Selection**
33

34 **Activation of B Cells**
- B cells differentiate into:
  - Antibody-producing plasma cells
  - Memory cells
  - Clonal deletion eliminates harmful B cells

35 **Antigen–Antibody Binding**
- Agglutination
- Opsonization
- Activation of complement
- Antibody-dependent cell-mediated cytotoxicity
- Neutralization

36

37
- Would pneumococcal pneumonia require a TH cell to stimulate a B cell to form antibodies? 17-6
- Plasma cells produce antibodies; do they also produce memory cells? 17-7
- In what way does a B cell that encounters an antigen function as an antigen-presenting cell? 17-8

38
- On what part of the antibody molecule do we find the amino acid sequence that makes the huge genetic diversity of antibody production possible? 17-9
- Antibodies and what other component of the immune system are required for the lysis of a target antigenic cell? 17-10

39 **T Cells and Cellular Immunity**
- 17-11 Describe at least one function of each of the following: M cells, TH cells, TC cells, Treg cells, CTLs, NK cells.
- 17-12 Differentiate T helper, T cytotoxic, and T regulatory cells.
- 17-13 Differentiate TH1, TH2, and TH17 cells.
- 17-14 Define apoptosis.

40 **T Cells and Cellular Immunity**
- T cells mature in the thymus
  - Thymic selection eliminates many immature T cells

41
**T Cells and Cellular Immunity**
- T cells respond to Ag by T-cell receptors (TCRs)
- T cells require antigen-presenting cells (APCs)
- Pathogens entering the gastrointestinal or respiratory tracts pass through:
  - M (microfold) cells over
  - Peyer’s patches, which contain APCs

**T Helper Cells**
- CD4+ or TH cells
  - TCRs recognize Ags and MHC II on APC
  - TLRs are a costimulatory signal on APC and TH
  - TH cells produce cytokines and differentiate into:
    - TH1 cells
    - TH2 cells
    - TH17 cells
    - Memory cells

**T Helper Cells**
- TH1 produce IFN-γ, which activates cells related to cell-mediated immunity, macrophages, and Abs
- TH2 activate eosinophils and B cells to produce IgE
- TH17 stimulate the innate immune system
- TF stimulate B cells to produce plasma cells and are involved in class switching

**Activation of CD4+ T Helper Cells**

**T Cytotoxic Cells**
- CD8+ or TC cells
- Target cells are self-cells carrying endogenous antigens
- Activated into cytotoxic T lymphocytes (CTLs)
  - CTLs recognize Ag + MHC I
  - Induce apoptosis in target cell
  - CTL releases perforin and granzymes

**T Regulatory Cells**
- Treg cells
• CD4 and CD25 on surface
• Suppress T cells against self

53

• What antibody is the primary one produced when an antigen is taken up by an M cell? 17-11
• Which T cell type is generally involved when a B cell reacts with an antigen and produces antibodies against the antigen? 17-12
• Which is the T cell type that is generally involved in allergic reactions? 17-13
• What is another name for apoptosis, one that describes its function? 17-14

54 T Cells and Cellular Immunity

• 17-15 Define antigen-presenting cell.
• 17-16 Describe the function of natural killer cells.
• 17-17 Describe the role of antibodies and natural killer cells in antibody-dependent cell-mediated cytotoxicity.
• 17-18 Identify at least one function of each of the following: cytokines, interleukins, chemokines, interferons, TNF, and hematopoietic cytokines.

55 Antigen-Presenting Cells

• Digest antigen
• Ag fragments on APC surface with MHC
  • B cells
  • Dendritic cells
  • Activated macrophages

56

57

58 Natural Killer (NK) Cells

• Granular leukocytes destroy cells that don’t express MHC I
• Kill virus-infected and tumor cells
• Attack parasites

59 ADCC

• Antibody-dependent cell-mediated cytotoxicity

60

61

62

63 Cytokines
• Chemical messengers
• Overproduction leads to cytokine storm

64 Cells Communicate via Cytokines
65 Cells Communicate via Cytokines
66
• Are dendritic cells considered primarily part of the humoral or the cellular immune system? 17-15
• How does the natural killer cell respond if the target cell does not have MHC class I molecules on its surface? 17-16
• What makes a natural killer cell, which is not immunologically specific, attack a particular target cell? 17-17
• What is the function of cytokines? 17-18

67 T Cells and Cellular Immunity

• 17-19 Distinguish a primary from a secondary immune response.
• 17-20 Contrast the four types of adaptive immunity.

68 Immunological Memory

• Antibody titer is the amount of Ab in serum
• Primary response occurs after initial contact with Ag
• Secondary (memory or anamnestic) response occurs after second exposure

69

70 Types of Adaptive Immunity

• Naturally acquired active immunity
  • Resulting from infection
• Naturally acquired passive immunity
  • Transplacental or via colostrum
• Artificially acquired active immunity
  • Injection of Ag (vaccination)
• Artificially acquired passive immunity
  • Injection of Ab

71 Terminology of Adaptive Immunity

• Serology: the study of reactions between antibodies and antigens
• Antiserum: the generic term for serum because it contains Ab
• Globulins: serum proteins
• Immunoglobulins: antibodies
• Gamma (γ) globulin: serum fraction containing Ab

72
• Is the anamnestic response primary or secondary? 17-19
• What type of adaptive immunity is involved when gamma globulin is injected into a person? 17-20