Specific Immunity and Vaccination

- **Natural immunity**: any immunity that is acquired through the normal biological experiences of an individual

- **Artificial immunity**: protection from infection obtained through medical procedures such as vaccines and immune serum

**Active immunity**
- occurs when an individual receives immune stimulus that activates B and T cells to produce immune substances such as antibodies
- creates memory that renders the person ready for quick action upon re-exposure to the same antigen
- requires several days to develop
- lasts for a relatively long time

**Passive immunity**
- occurs when an individual receives antibodies from another source
  - recipient is protected for a short period of time
  - transfer of antibodies from mother to child in utero or through breastfeeding
  - transfusion of gamma globulin
  - anti-snake venom
The acquired immune response counters specific invaders

- **Our immune system**
  - Responds to foreign molecules called antigens
- **The acquired immune system**
  - Reacts to antigens
  - And “remembers” an invader

Antigens have specific regions where antibodies bind to them

- **Antigens**
  - Most are proteins or polysaccharides on the surfaces of
    - Viruses
    - Foreign cells
- **Antigenic determinants**
  - Specific regions on an antigen
  - To which antibodies bind

Lymphocytes mount a dual defense

- **Two kinds of lymphocytes** carry out the immune response
  - **B cells**
    - Secrete antibodies
  - **T cells**
    - Attack cells infected with bacteria or viruses
  - **Millions of kinds of B cells and T cells**
    - Each with different membrane receptors
Clonal selection musters defensive forces against specific antigens

- When an antigen enters the body
  - It activates only a small subset of lymphocytes
  - Those with complementary receptors
- The selected lymphocyte cells multiply into clones (copies) of short-lived effector cells
  - Specialized for defending against the antigen that triggered the response
  - And into memory cells that confer long-term immunity

The steps of clonal selection

- Primary immune response, clonal selection
  - Produces effector cells
  - Memory cells that may confer lifelong immunity
- Secondary immune response
  - Memory cells are activated by a second exposure to the same antigen
  - This initiates a faster and stronger response
Clonal selection musters defensive forces against specific antigens

- Primary vs. secondary immune response
  - The primary immune response
    - Occurs upon first exposure to an antigen
    - Is slower than the secondary immune response
  - The secondary immune response
    - Occurs upon second exposure to an antigen
    - Is faster and stronger than the primary immune response

**Immunization: A Lively History**

- First recorded attempt at immunization occurred in the 6th century China
  - consisted of drying and grinding up smallpox scabs and blowing them with a straw into the nostrils of vulnerable family members

- Variolation in the 10th century
  - deliberate inoculation of dried pus from smallpox pustules of one patient into scratches on the arm of a healthy person
  - used in parts of the Far East until Lady Montagu brought it to England in 1721
  - unfortunately, many recipients and their contacts still died of smallpox

**Immunization: A Lively History**

- Edward Jenner: 1796
  - inspired by a dairymaid who had been infected by cowpox and who was immune to smallpox
  - tested his theory by injecting a young boy with material from human cowpox lesions, exposed him to smallpox 2 months later, and was immune to the disease
  - vaccination: any immunity obtained by inoculation with selected antigens
Artificial Active Immunity: Vaccination

• Basic principles behind vaccination
  – stimulate a primary response and a memory response
  – prime the immune system for future exposure to a virulent pathogen
  – if the pathogen enters the body, the response will be immediate, powerful, and sustained

• Vaccines have profoundly reduced the prevalence and impact of many infectious diseases that were once common and deadly

Principles of Vaccine Preparation

• Qualities of an effective vaccine
  – protect against exposure to natural, wild forms of the pathogen
  – have a low level of adverse side effects or toxicity
  – stimulate both antibody (B-cell) and cell-mediated (T-cell) response
  – long-term, lasting effects (produce memory)
  – not require numerous doses or boosters
  – inexpensive, have a relatively long shelf life, and be easy to administer

Principles of Vaccine Preparation

• Whole cell or virus vaccines
  – live, attenuated cells or viruses
  – killed cells or inactivated viruses

• Antigenic molecules derived from bacterial cells or viruses (subunits)
  – subunits derived from cultures of cells or viruses
  – subunits synthesized to mimic natural molecules, often via genetic engineering
  – conjugated vaccines: subunits attached to proteins to make them more immunogenic

Development of New Vaccines

• Dozens of bacterial, viral, protozoan, and fungal diseases remain without a functional vaccine
  – malaria, HIV/AIDS, diarrheal diseases, respiratory diseases, and worm infections that affect over 200 million people per year

• Difficult to design vaccines for latent or persistent viral infections
  – herpesviruses and cytomegaloviruses
**Route of Administration and Side Effects of Vaccines**

• Most vaccines are administered via the routes below
  - subcutaneous
  - intramuscular
  - intradermal
  - nasal and oral vaccines
    - available for only a few diseases

**Vaccine Administration**

• **Adjuvant:** special binding substance required by some vaccines
  - enhances immunogenicity
  - precipitates the antigen and holds it in the tissues so that it will be released gradually
  - most common adjuvant: alum (aluminum hydroxide salts)

**Vaccine Side Effects**

• Vaccines must go through years of trials in experimental animals and human volunteers before they are licensed for general use

• Still some complications occur
  - local reactions at the injection site
  - fever
  - allergies
  - some rare adverse reactions

**Vaccine Side Effects**

• Recent studies have attempted to link vaccines to later development of diabetes, asthma, and autism
  - the study linking the MMR vaccine to autism has been discredited and the principal author’s medical license was revoked
  - independent studies have shown, unequivocally, that the MMR vaccine does not cause autism
Vaccine Side Effects

• Price of not vaccinating
  - outbreaks of measles, mumps, diphtheria, polio, typhoid fever, and whooping cough
  - decrease in the level of herd immunity, a phenomenon in which a certain percentage of the population is vaccinated, making it impossible for the microbe to circulate

• Getting vaccinated serves the common good, as well as the individual good

• Many young parents have no memory of the pre-vaccination era and don’t appreciate the greater risk of not vaccinating their children

Vaccine Side Effects

• In the decade before the measles vaccine was available
  - 3 – 4 million cases of measles per year
  - 300 – 400 children died annually
  - 1000 more chronically disabled due to measles encephalitis

• Childhood vaccines save the lives of 2.5 million children a year worldwide (UNICEF)

• Risks from infectious disease almost always outweigh the chance of an adverse vaccine reaction

To Vaccinate: Who and When?

• Caution must be exercised in giving live vaccines to immunocompromised or pregnant patients

• Vaccination recommended for all typical childhood diseases for which a vaccine is available

• Vaccination in adults to “boost” older immunizations, protect against adult infections, and to provide special protection in people with certain medical conditions

Concept Check

Determine which of the statements below describes active or passive immunity:

A. infusion of gamma globulin
B. recovery from influenza
C. receipt of the influenza vaccination
D. antibodies passed from mother to infant through breastfeeding