NOVA

Charting New Horizons in Education

Introduction to Immunity

01

Immunology

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Learning objectives

- **1. Definitions and Characteristics**
  Antigen
  Immunogen
  Hapten
  Epitope
  Adjuvant

- 2. **Identify the factors that affect the immunogenicity**

- 3. **Understand the concept of antigen cross reactivity**

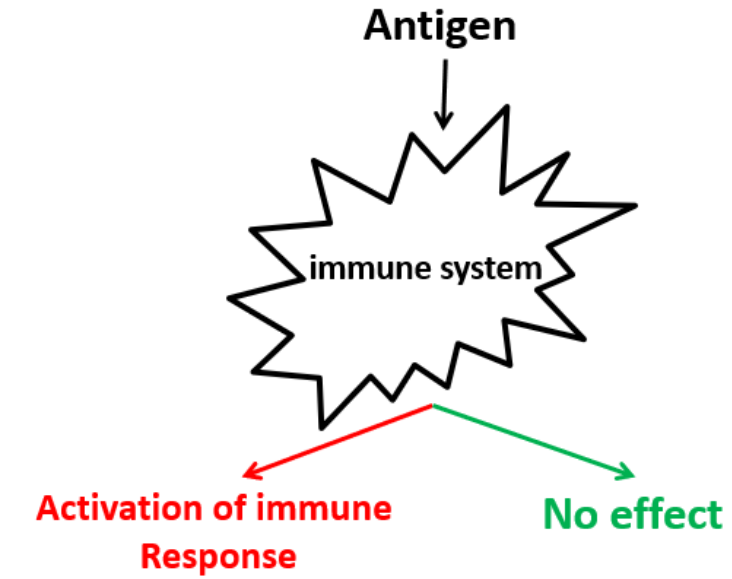
- 4. **Differentiate between active, passive, and adoptive immunity**

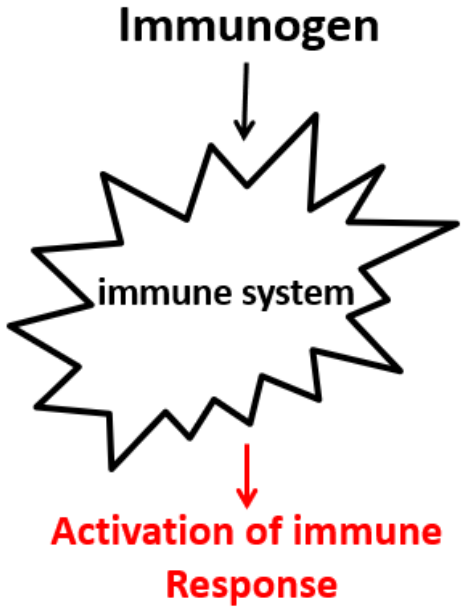
History of Immunology

- The earliest known reference to immunity was during the plague of Athens in 430 BC
- In the 18th century, scientist made experiments with scorpion venom and observed that certain dogs and mice were immune to this venom.
- **Immunology;**
  - Study of the components and function of the immune system.
- **Immune System;**
  - Molecules, cells, tissues, and organs providing non-specific and specific protection against:
    - Microorganisms
    - Microbial toxins
    - Tumor cells

Antigens & Immunogens

- Foreign substances that induce an immune response are of two types:
- a. **Immunogen**
  - A substance capable of inducing a specific immune response, resulting in the formation of antibodies or immune lymphocytes.
- b. **Antigen**
  - Any molecule that can bind to components of the immune system (lymphocytes, antibodies, and T cell receptors) without necessarily inducing an immune response.
- Immunogenic substances are always antigenic, whereas antigens are not necessarily immunogenic (e.g., autologous serum proteins).
- **Distinction;** The distinction between antigen and immunogen is functional.





Antigens & Immunogens

Antigens (Food particles, dust, microorganisms)

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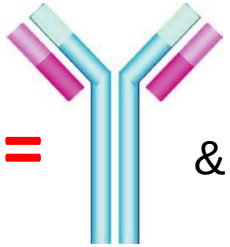

& Active WBCs

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Antigen is considered immunogen

Antigens (Food particles, dust, microorganisms)

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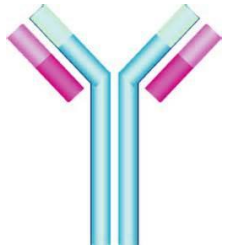

No activation

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Antigen is considered non-immunogen (Just an antigen)

Antigens & Immunogens

Blood antigens in this case are considered Non-immunogens (Autologous donation)

Blood group A

Blood group B

Blood antigens in this case are considered immunogens (Heterologous donation)

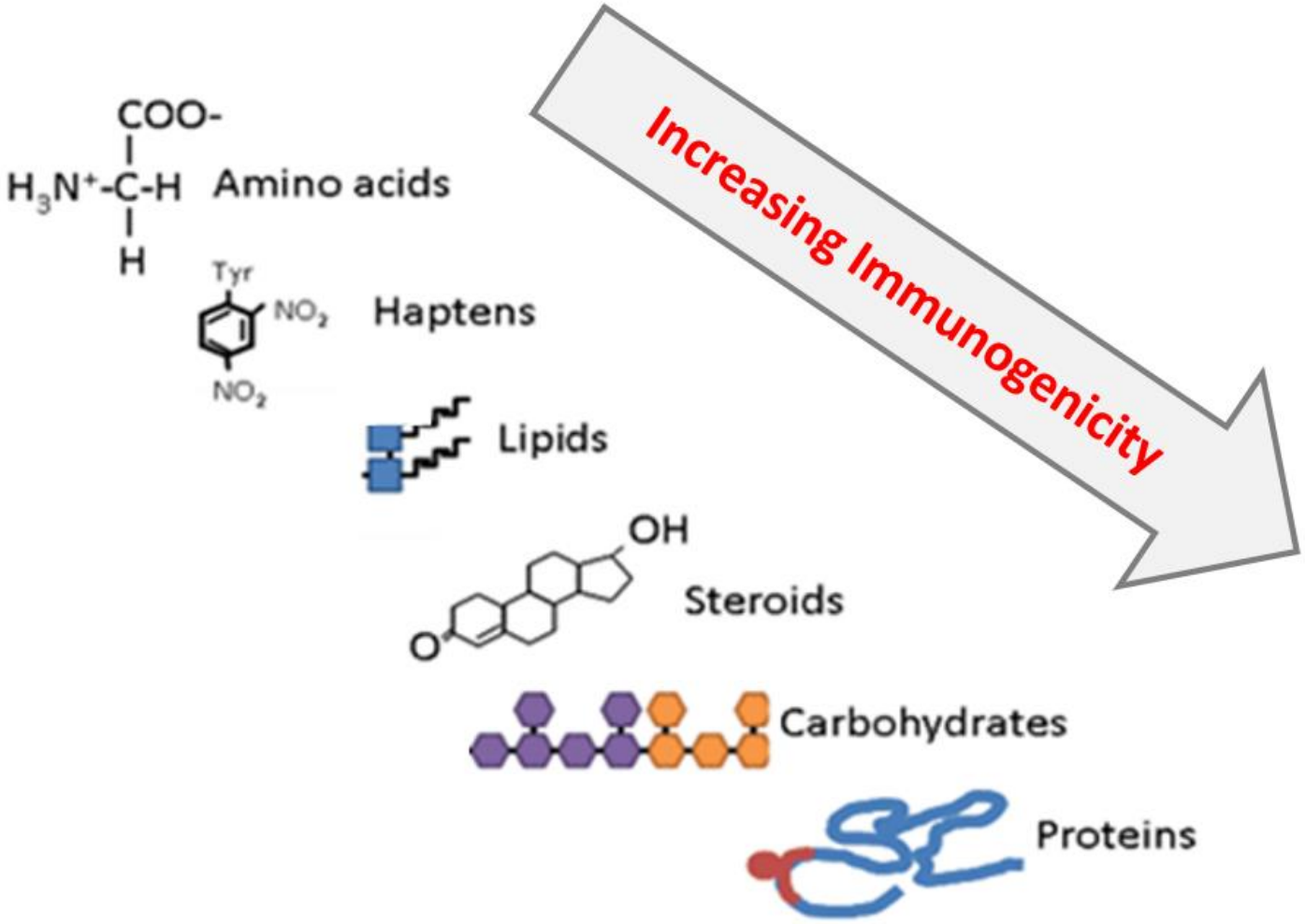
Factor affecting Immunogenicity

1. **Nature of the Immunogen;**
   - **Foreignness**: Animals typically do not respond to self-antigens.
     Compounds that are part of self are not immunogenic to the individual.
   - **Molecular Weight**: A minimal molecular weight is required for immunogenicity.
     - <1000 daltons: Not immunogenic (e.g., penicillin, progesterone, aspirin).
     - 1000-6000 daltons: May or may not be immunogenic (e.g., insulin).
     - >6000 daltons: Are immunogenic (e.g., albumin, tetanus toxin).
   - **Chemical Structure Complexity**: Heteropolymers containing two or more different amino acids are more immunogenic than homopolymers.

2. Biological Factors

- Dosage
- route of administration
  (Subcutaneous > Intravenous > Intragastric)
- individual genetic differences
- the use of adjuvants.

Factor affecting Immunogenicity

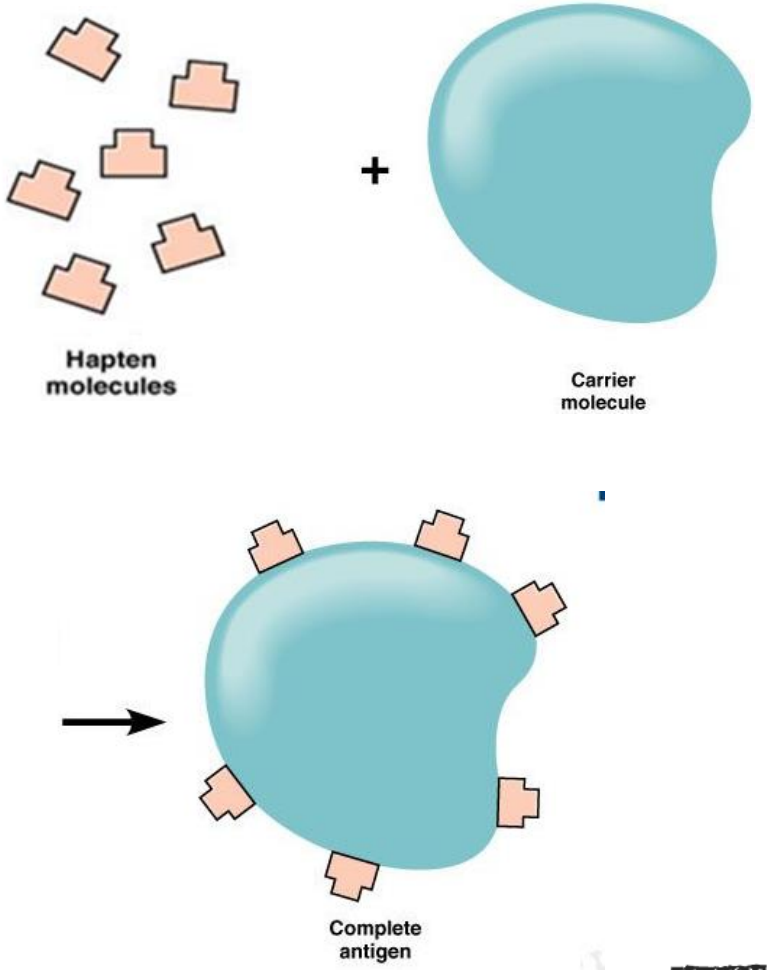


Adjuvants

1. **Definition:**
    1. Substances that enhance immunogenicity without altering chemical composition.
    2. Substances which when mixed with an immunogen enhance the immune response against the **immunogen (Immunopotentiator or Immuno-booster).**
2. **Examples:**
    1. **Inorganic Compounds:** Alum, aluminum hydroxide
    2. **Mineral Oil:** Paraffin oil
    3. **Bacterial Products:** Killed bacteria (Bordetella pertussis, Mycobacterium bovis), toxoids
    4. **Freund's** complete adjuvant, **Freund's** incomplete adjuvant
3. **Mechanisms of Action:**
    1. Extend antigen presence in blood
    2. Aid in antigen absorption by presenting cells
    3. Activate macrophages and lymphocytes
    4. Support cytokine production

Haptens

1. **Definition:** Nonantigenic molecules with low molecular weight (too small to be immunogenic) that cannot induce an immune response by themselves but react with products of that response.
2. **Examples:**
    1. Antibiotics
    2. Analgesics
    3. Other low-molecular weight compounds
3. **Conversion to Antigen:** When a hapten is coupled to a larger carrier molecule (e.g., albumins, globulins, synthetic polypeptides), it becomes a complete antigen (immunogen).
4. **Clinical Significance:** Certain haptens, such as penicillin, can cross-react with self-proteins, causing allergic responses.
5. **Auto coupling Haptens:**
    - Some haptens can form spontaneous covalent bonds with self-proteins, creating new antigens in vivo.
      This can lead to: Autoimmune diseases or Drug allergies



Haptens

Hapten

No activation for immune response
(No antibody production)

Exposure to hapten and carrier protein

Hapten → **Carrier protein**

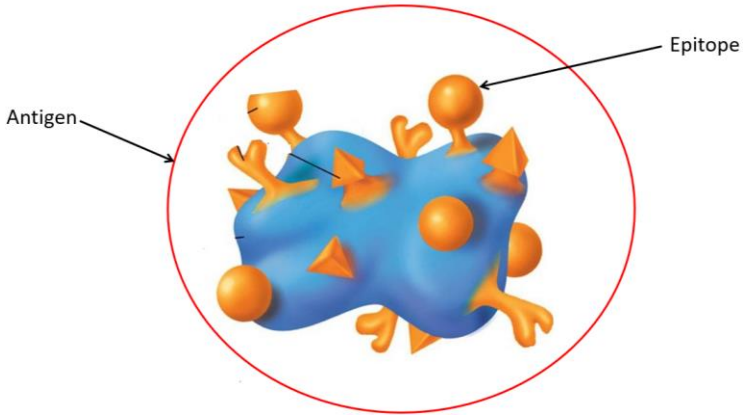
Activation for immune response and antibody production →

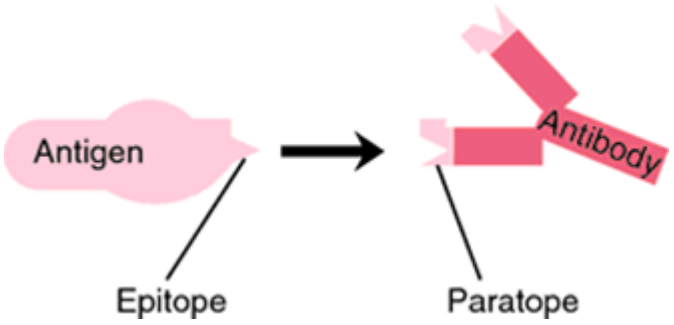
Drug Allergy

1. **Definition:** Adverse immunological reactions to certain antigens, particularly antibiotics, which can pose significant medical problems.
2. **Examples:** Anaphylactic reactions to penicillin can be fatal.
3. **Mechanism of Reaction:**
    - Penicillin can form a hapten-carrier conjugate with self-proteins, acting as an immunogen that generates IgE antibodies.
    - IgE antibodies bind to mast cells.
    - During the second exposure, penicillin binds directly to IgE, activating mast cell degranulation.
4. **IgE Cross-Reactivity:**
    - Some anti-penicillin IgE antibodies cross-react with other antibiotics that have similar structures, such as cephalosporins and carbapenems.
    - This complicates the treatment of bacterial infections in affected patients, as they may be unable to take necessary antibiotics.

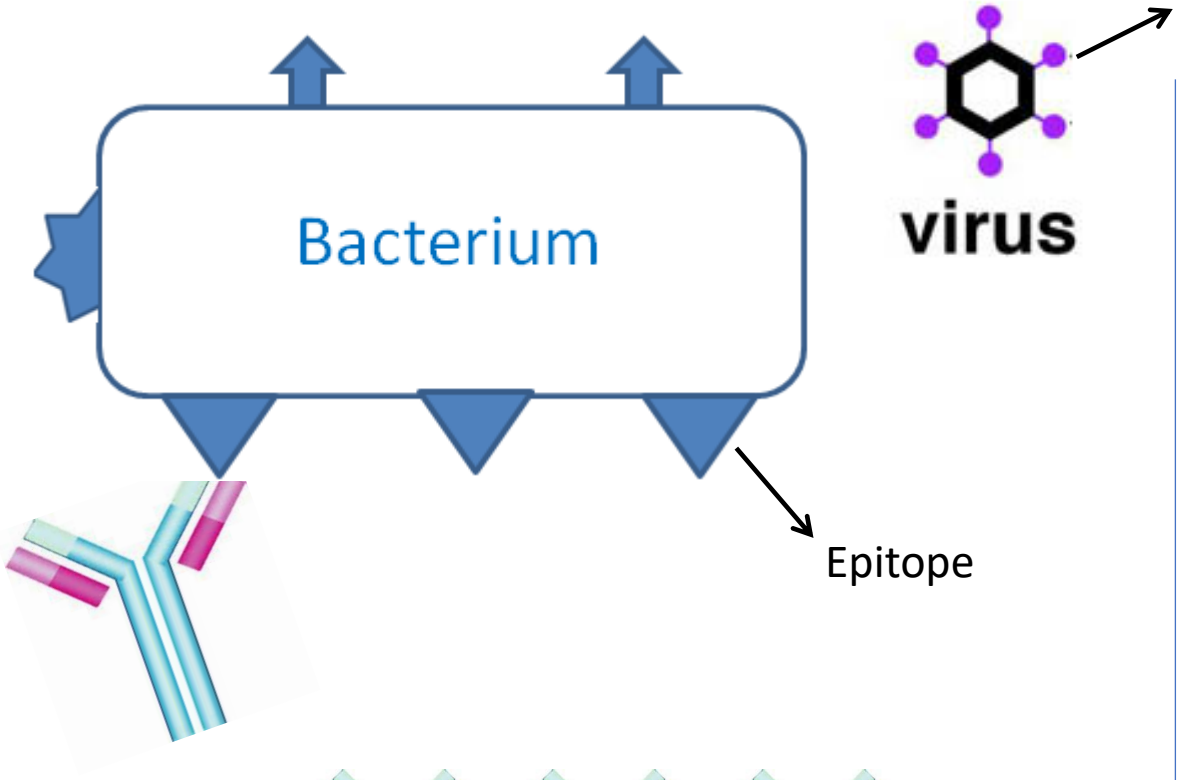
Epitopes

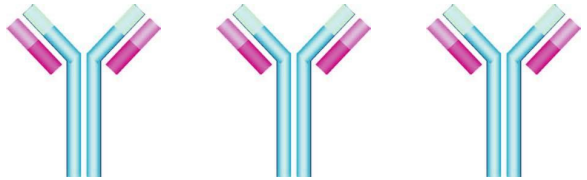
1. **Definition:** Also known as antigenic determinants, epitopes are the sites on or within an antigen that antibodies react with.
2. **Comparison with Haptens:** Epitopes and haptens are similar, but:
    1. Haptens are artificially added to a molecule.
    2. Epitopes are integral parts of the native molecule.
3. **Size:** Epitopes are very small, typically consisting of just four or five amino acid or monosaccharide residues.
4. **Types of Antigens:**
    - Antigens with many epitopes of different specificities are called **polyvalent**.
    - Antigens with many epitopes of the same specificity are called **multivalent**.
5. **Diversity of Epitopes:** An antigen molecule can carry a number of different epitopes, specifying different antibodies.



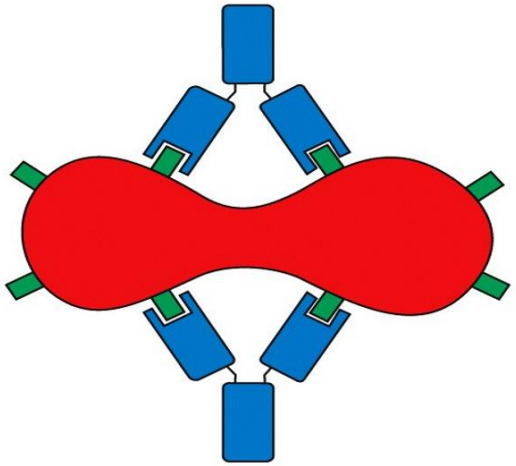


Epitopes

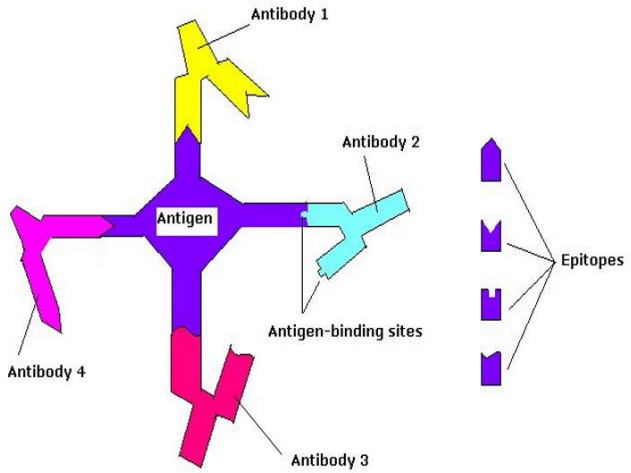




Antibodies are produced after an immune response



multivalent antigen with similar epitopes



Multivalent antigen with different epitopes

Characteristics of the Immune Response

- The immune response has several generalized features that distinguish it from other body systems, such as the respiratory and reproductive systems.
- **Key Features:**
  a. **Specificity:** The ability to discriminate among different molecular entities rather than making a random, undifferentiated response.

  b. **Discrimination:** The ability to differentiate between “self” and “nonself” antigens.

  c. **Memory:** The ability to recall previous contact with foreign molecules and respond to them in a learned manner, resulting in a more rapid and larger response.

Types of Immunity

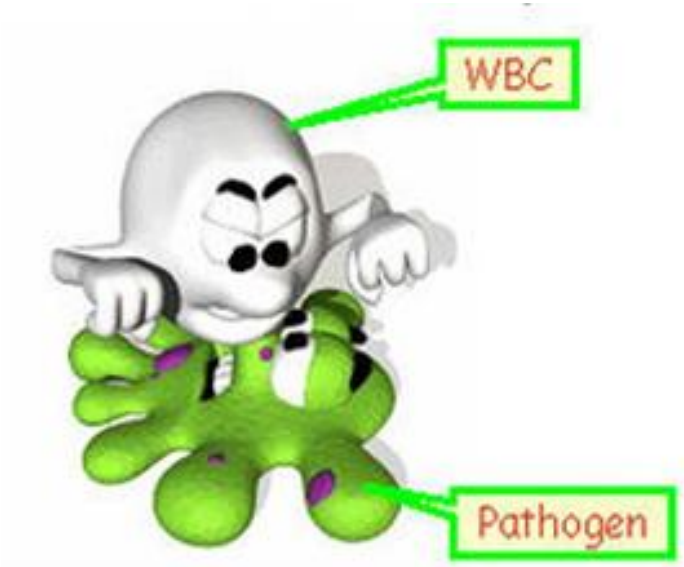
1. **Acquired Immunity:**
   a. **Natural Acquired Immunity:**
      1. **Active Immunity:**
         - Antigens enter the body naturally, triggering responses from both the innate and adaptive immune systems.
         - Provides long-term protection.
      2. **Passive Immunity:**
         - Antibodies pass from mother to fetus across the placenta.
         - Infants receive antibodies through breast milk.
         - Provides immediate short-term protection.

   b. **Artificial Acquired Immunity:**
      1. **Active Immunity:**
         - Antigens enter the body through vaccination, prompting responses from innate and adaptive immune systems.
         - Provides long-term protection.
      2. **Passive Immunity:**
         - Transfer of antibodies from immune individuals to a recipient.
         - Provides immediate short-term protection.

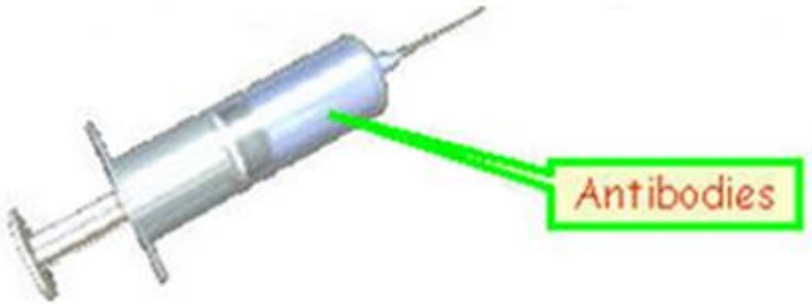
2. **Adoptive Immunity:**
   Refers to the transfer of immunity through the transfer of immune cells.

Routes of acquiring immunity

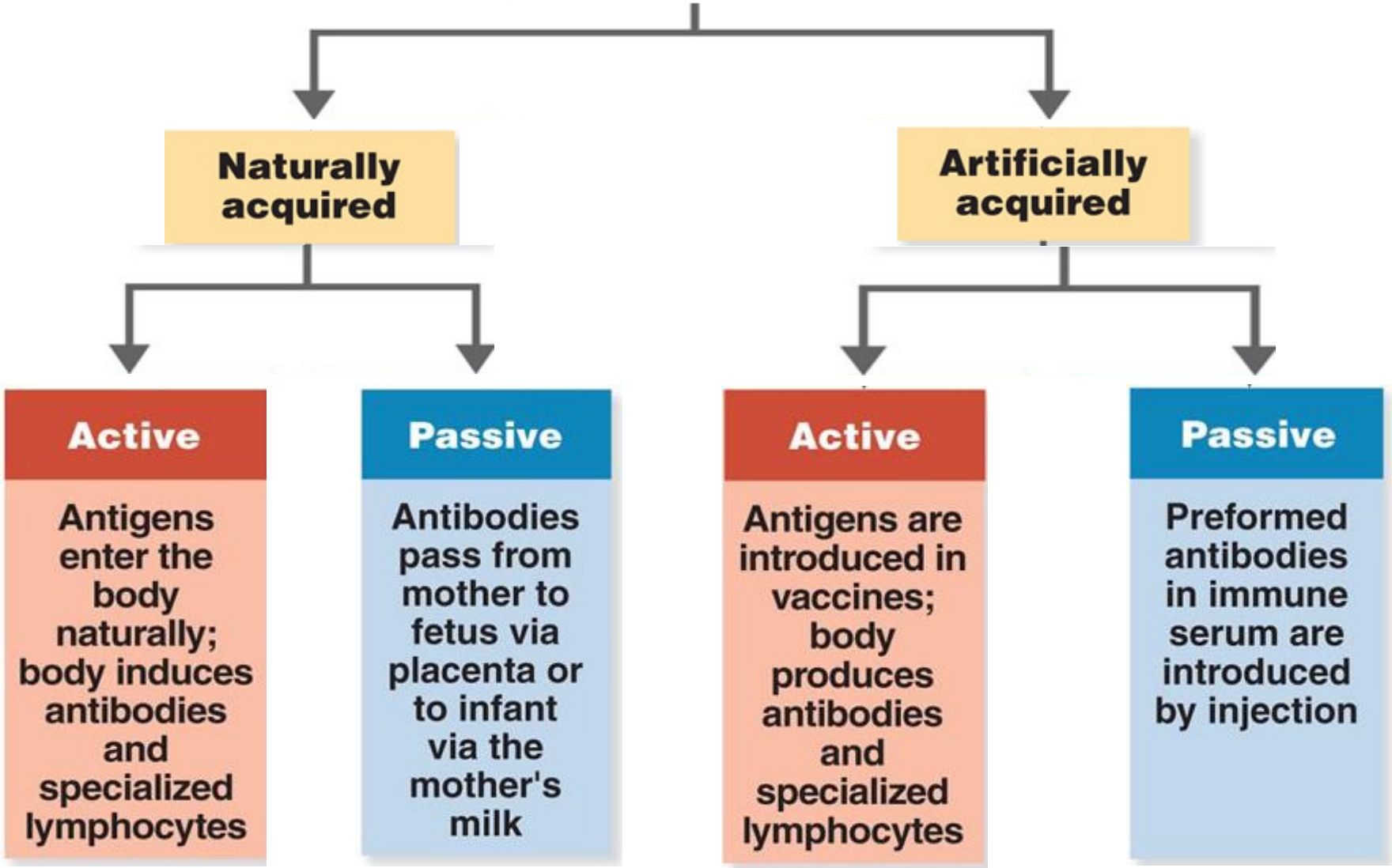
Active Immunity: Reaction of your own immune system



Passive Immunity: Borrow immune agents from other person



Acquired Immunity



Thank you

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