Principles of Vaccination

Pink Book Web-on-Demand Series
July 5, 2022

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Learning Objectives

- Describe the Advisory Committee on Immunization Practices General Best Practice Guidelines on Immunization.
- Describe an emerging immunization issue.
- For each vaccine-preventable disease, identify those for whom routine immunization is recommended.
- For each vaccine-preventable disease, describe characteristics of the vaccine used to prevent the disease.
- Locate current immunization resources to increase knowledge of team's role in program implementation for improved team performance.
- Implement disease detection and prevention health care services (e.g., smoking cessation, weight reduction, diabetes screening, blood pressure screening, immunization services) to prevent health problems and maintain health.

Continuing Education Information

- **CE credit, go to**: https://tceols.cdc.gov/
- **Search course number: WD4564-070522**
- **CE credit expires: July 1, 2024**
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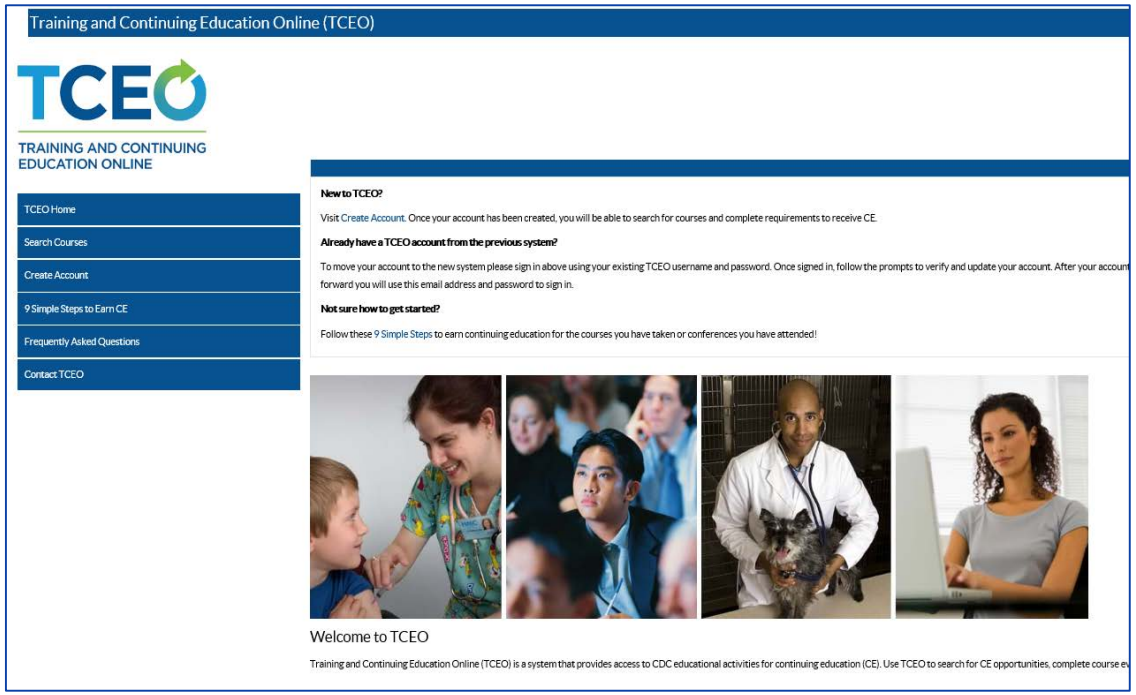

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1

Immunity

Human Immune System

- Complex network of interacting cells and proteins whose purpose is to identify, and eliminate, foreign substances

Immunity

- **The ability of the human body to:**
  - Tolerate the presence of material indigenous to the body, and
  - To eliminate foreign substances

- **Self vs. “non-self”**

Immunity, cont.

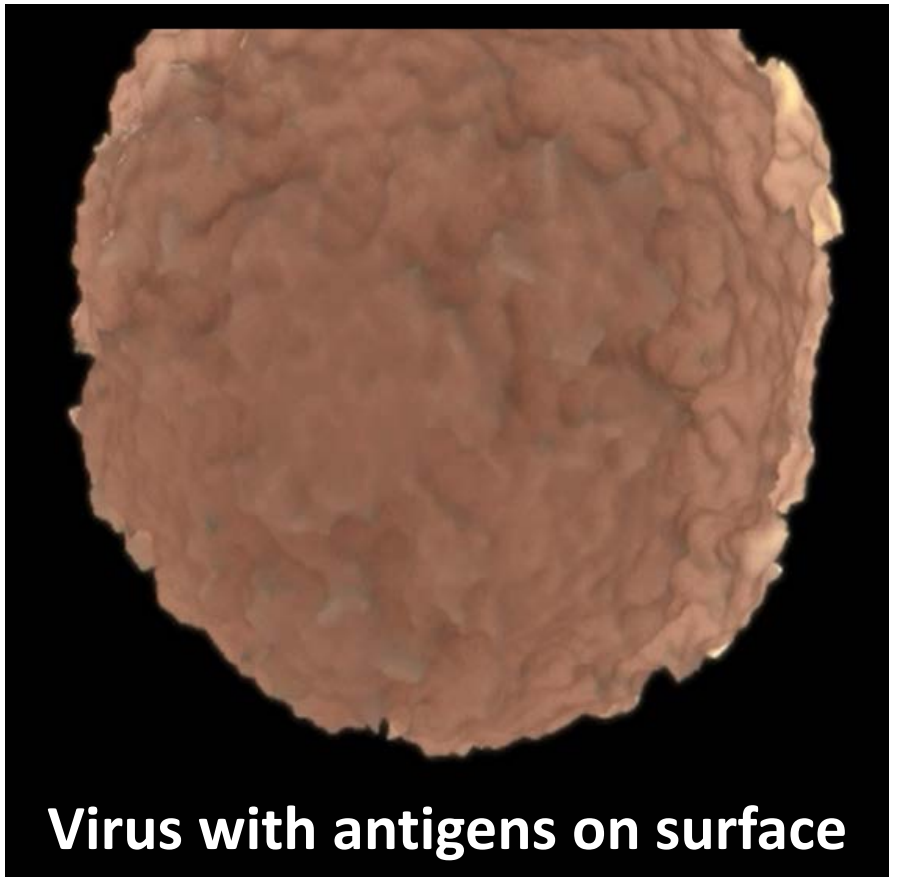
- **Most organisms recognized as foreign**
  - Virus, bacteria, fungi
  - Immune system provides protection from infectious diseases

- **Immunity is generally specific to a single organism**
  - Or a group of closely related organisms

Antigen

- **Live or inactivated substances (e.g., viruses, bacteria, toxins)**
  - Capable of stimulating an immune response

- **Antigen = antibody generator**

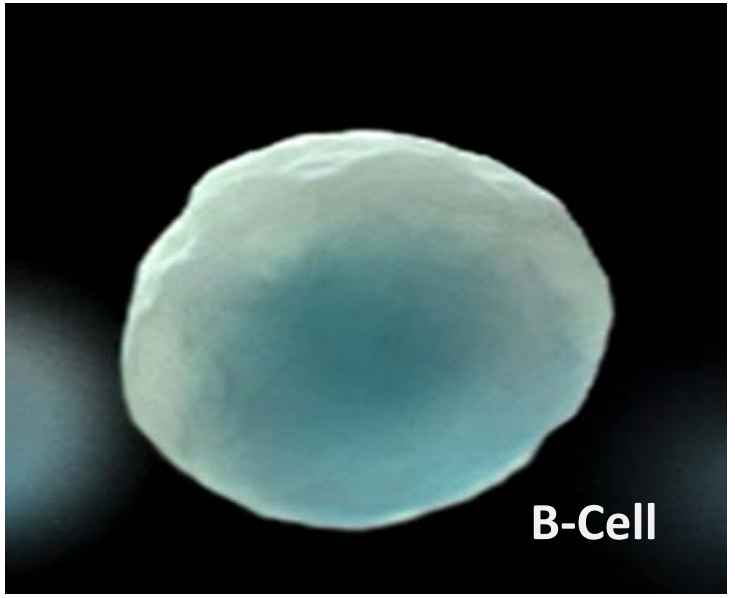


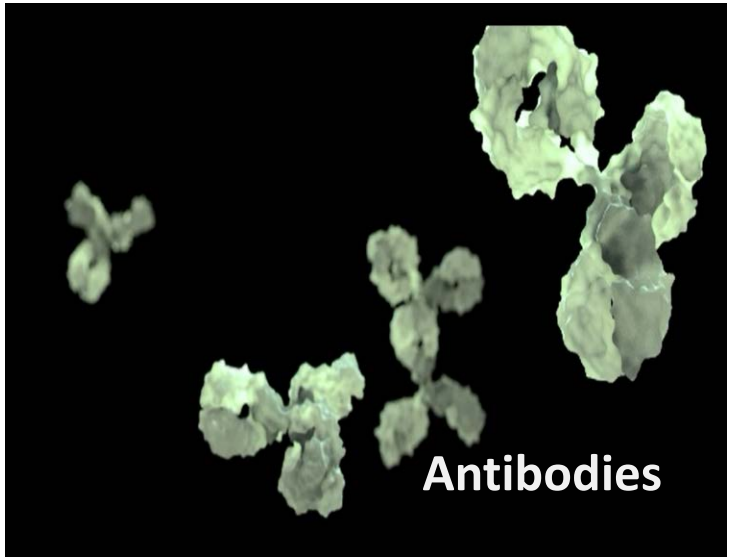
Virus with antigens on surface

Antibody

- Protein molecules (immunoglobulins)
- Help infection-fighting cells recognize and kill the microorganism

- Antibodies = are produced by the body





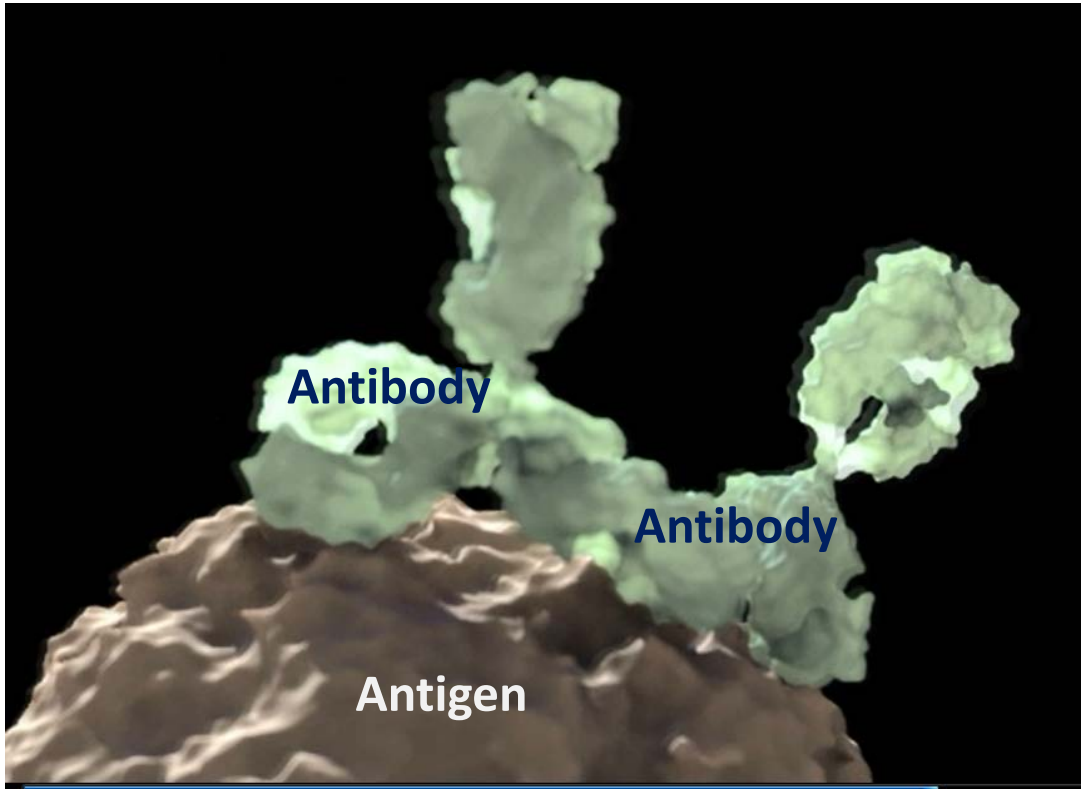
Arms of the Immune System

- Humoral
- Cell-mediated

Antigen

Arms of the Immune System, cont.

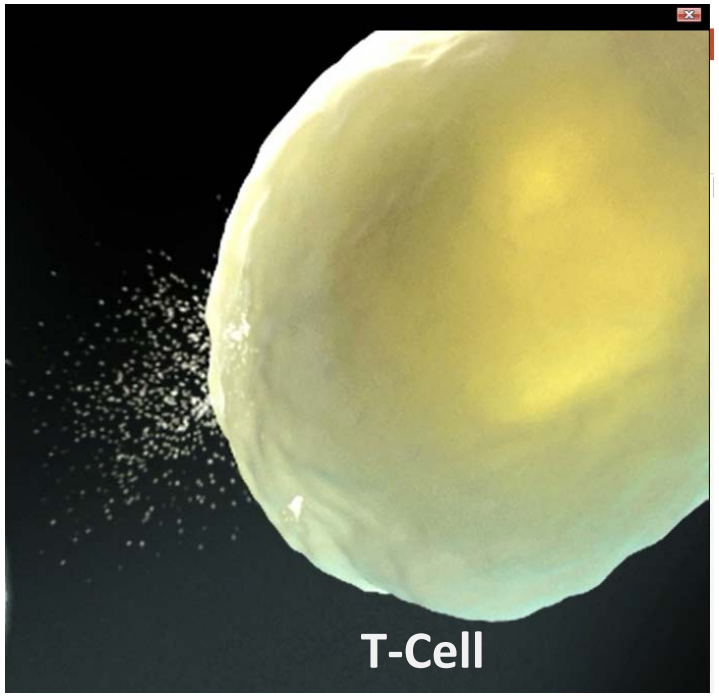
- **Humoral**
  - Antibodies attach to invading organism and interfere with its ability to produce more invading organisms
  - Antibodies are produced by B-cells (lymphocytes) to bind to a corresponding antigen (lock and key mechanism)
  - B-cells develop in the bone marrow



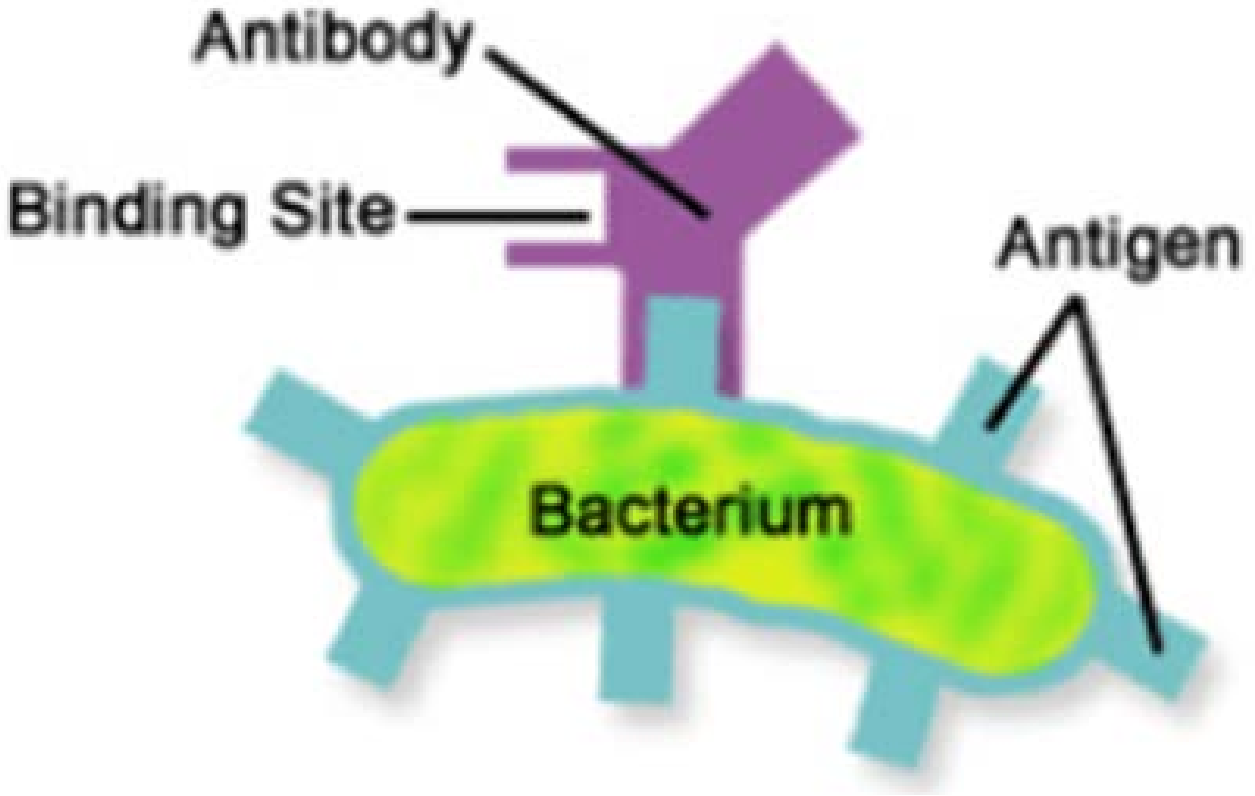
Antibodies attaching to antigens

Arms of the Immune System, cont.

- **Cell-mediated**
  - Involves the activation of T-cells, macrophages, and other substances that eliminate the antigen
  - T-cells mature in the thymus gland



Immune System



www2.cdc.gov/nip/isd/ycts/mod1/courses/gbp/index.html

Knowledge Check

- **Which of the following helps infection-fighting cells recognize and kill a microorganism?**

- A. Antigen
- B. Antibody

Answer

- **Which of the following helps infection-fighting cells recognize and kill a microorganism?**

- ~~A. Antigen~~
- **B. Antibody**

2

Types of Immunity: Passive and Active

Types of Immunity

- Passive immunity
- Active immunity

Passive Immunity

- **Transfer of antibody produced by one human or animal to another**
  - Transfer of antibody through placenta – important to protect infants

- **Temporary protection that wanes with time**

Sources of Passive Immunity

- **Many types of blood or blood products**

- **Homologous pooled human antibody (immune globulin or IG)**
  - IgG antibody from the blood of thousands of adult donors
  - Hepatitis A and measles post-exposure prophylaxis (PEP)

Sources of Passive Immunity, cont.

- **Homologous human hyperimmune globulin (e.g., HBIG)**
  - From donors with high concentrations of a specific antibody
  - HBIG, RIG, TIG, VariZIG, VIG
- **Heterologous hyperimmune serum**
  - Antitoxin (e.g., diphtheria antitoxin)
  - Serum sickness

Sources of Passive Immunity, cont.

- **Monoclonal antibodies**
  - Derived from a single type, or clone, of antibody-producing cells (B-cells)
    - Immune globulin from human sources is polyclonal (contains many kinds of antibodies)
  - Antibody is specific to a single antigen or closely related group of antigens
  - Used for diagnosis of and therapy for certain cancers and autoimmune and infectious diseases, as well as prevention of transplant rejection
  - Monoclonal-antibody-derived drugs end in –mab (i.e., palivizumab)

Antibody for Prevention of RSV

- **Palivizumab (Synagis)**
  - Monoclonal
  - Contains only RSV antibody
  - Will not interfere with the response to a live-virus vaccine

Passive Immunity Video

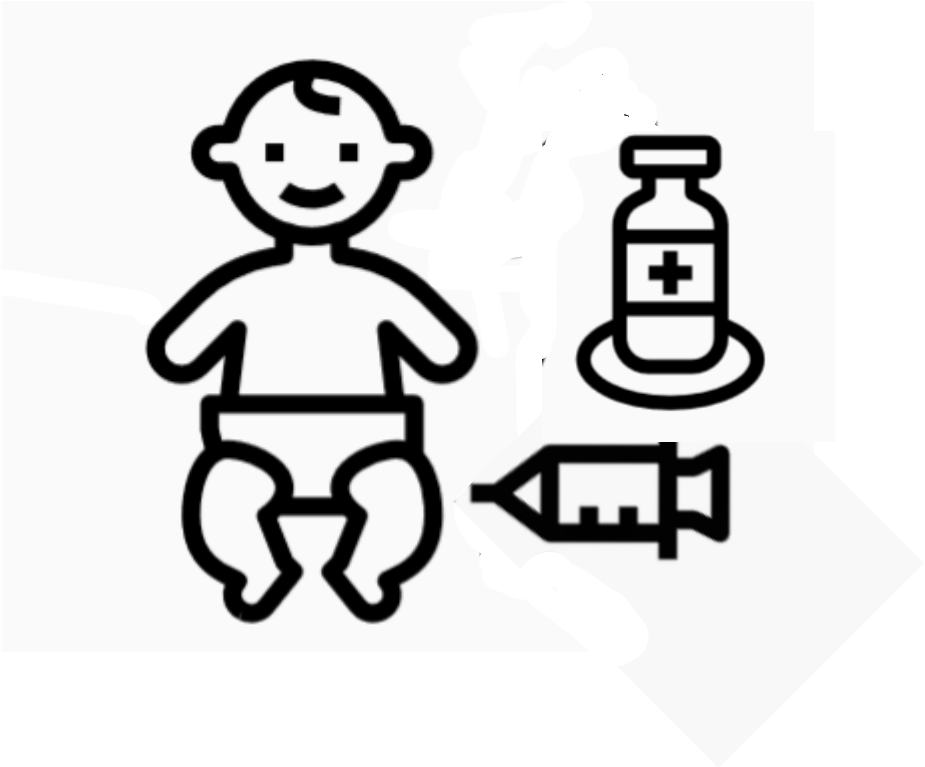
Active Immunity

- Protection produced by a person's own immune system
- Lasts for many years, often lifetime

Sources of Active Immunity

- Infection with disease-causing form of organism

- Vaccination



Vaccination

- **Active immunity produced by vaccine**
  - Vaccine delivers an attenuated (weakened, nonpathogenic) or dead form of the pathogen

- **Immunity and immunologic memory similar to natural infection but without risk of disease**
  - Immunologic memory allows for an anamnestic response after the primary immune response so that antibody reappears when the antigen is introduced

Active Immunity Video

Knowledge Check

- **Which type of immunity lasts longer?**

- A. Passive immunity
- B. Active immunity

Answer

- **Which type of immunity lasts longer?**

- ~~A. Passive immunity~~
- **B. Active Immunity**

3

Principles of Vaccination

Principles of Vaccination

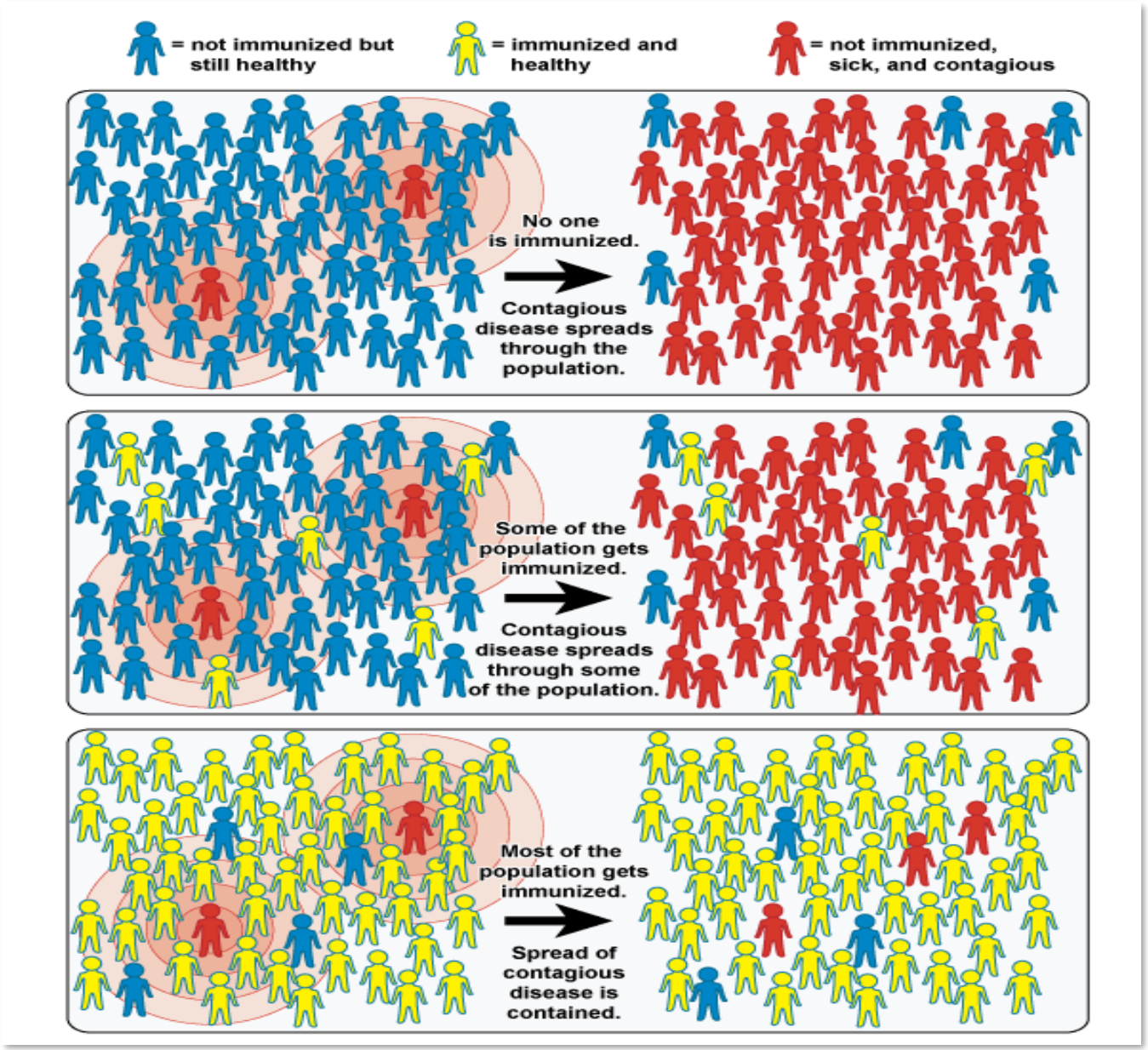
- **General rule:**
  - The more similar a vaccine is to the natural disease, the better the immune response to the vaccine.

Factors that Affect Immune Response to Vaccines

- **Presence of maternal antibodies**
- **Nature and amount of antigen in vaccine**
- **Route of administration**
- **Presence of an adjuvant (ingredient that promotes a stronger immune response)**
- **Storage and handling of vaccine**
- **Vaccine recipient**
  - Age
  - Nutritional status
  - Genetics
  - Coexisting disease

Community Immunity

- When a significant portion of the population is immune and provides protection for individuals who are not immune
- Also known as *herd immunity*



4

Classification of Vaccines

Classification of Vaccines

- **Live**
  - Most live vaccines used in the United States are “live attenuated,” meaning that the microbe in the vaccine is alive but has been weakened (attenuated)

- **Non-live**

Classification of Vaccines, cont.

- **Live**
  - Viral or bacterial
- **Non-live**
  - Viral or bacterial

Classification of Vaccines, cont.

- **Live**

- **Non-live**
  - Whole-cell
  - Subunit
  - Toxoid
  - Recombinant
  - mRNA

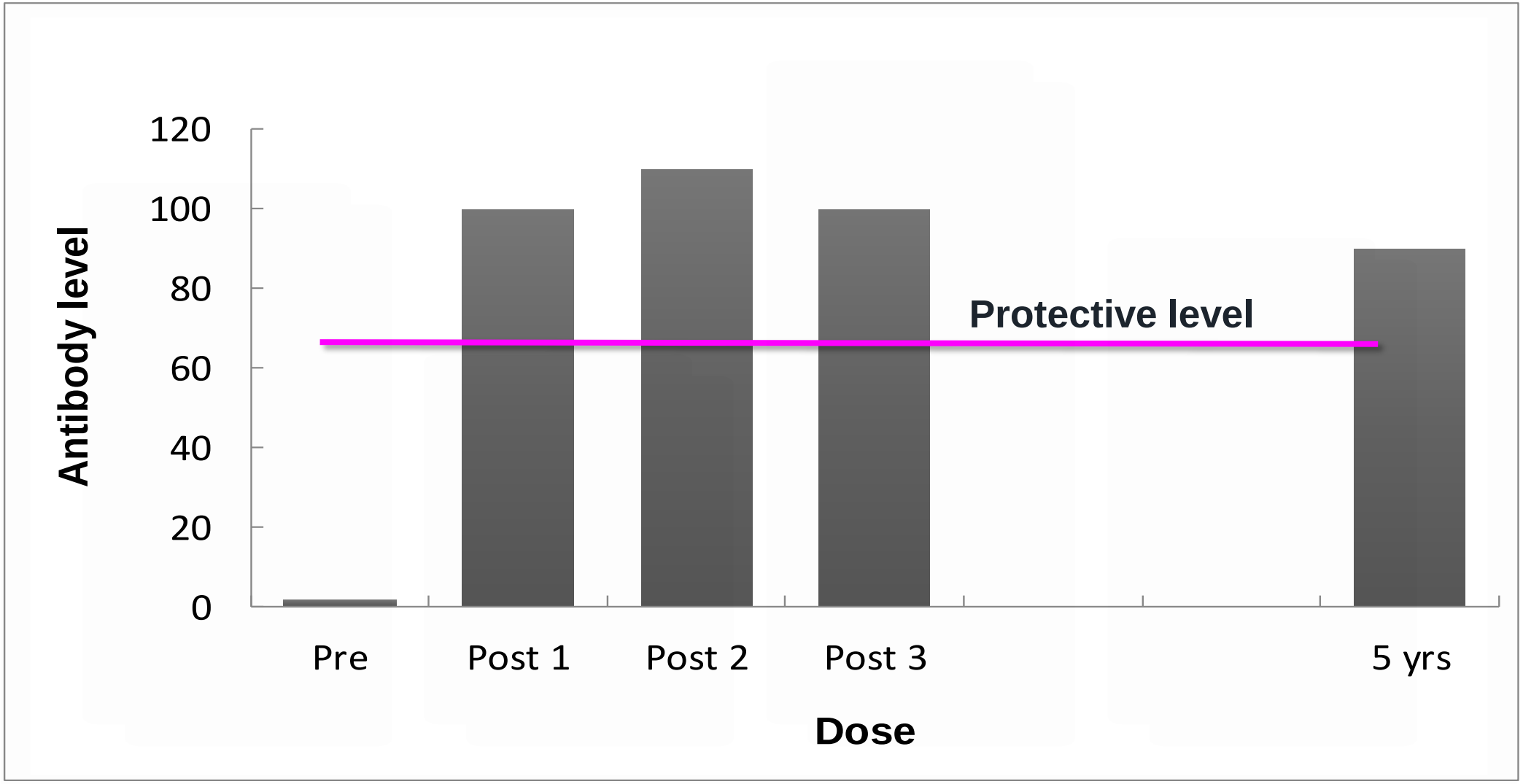
Live Vaccines

- **“Wild” virus or bacterium weakened by repeated passage in culture media**
- **Must replicate to produce an immune response**
- **Immune response virtually identical to natural infection**
- ***Usually* produce immunity with 1 dose**
  - Except those administered orally

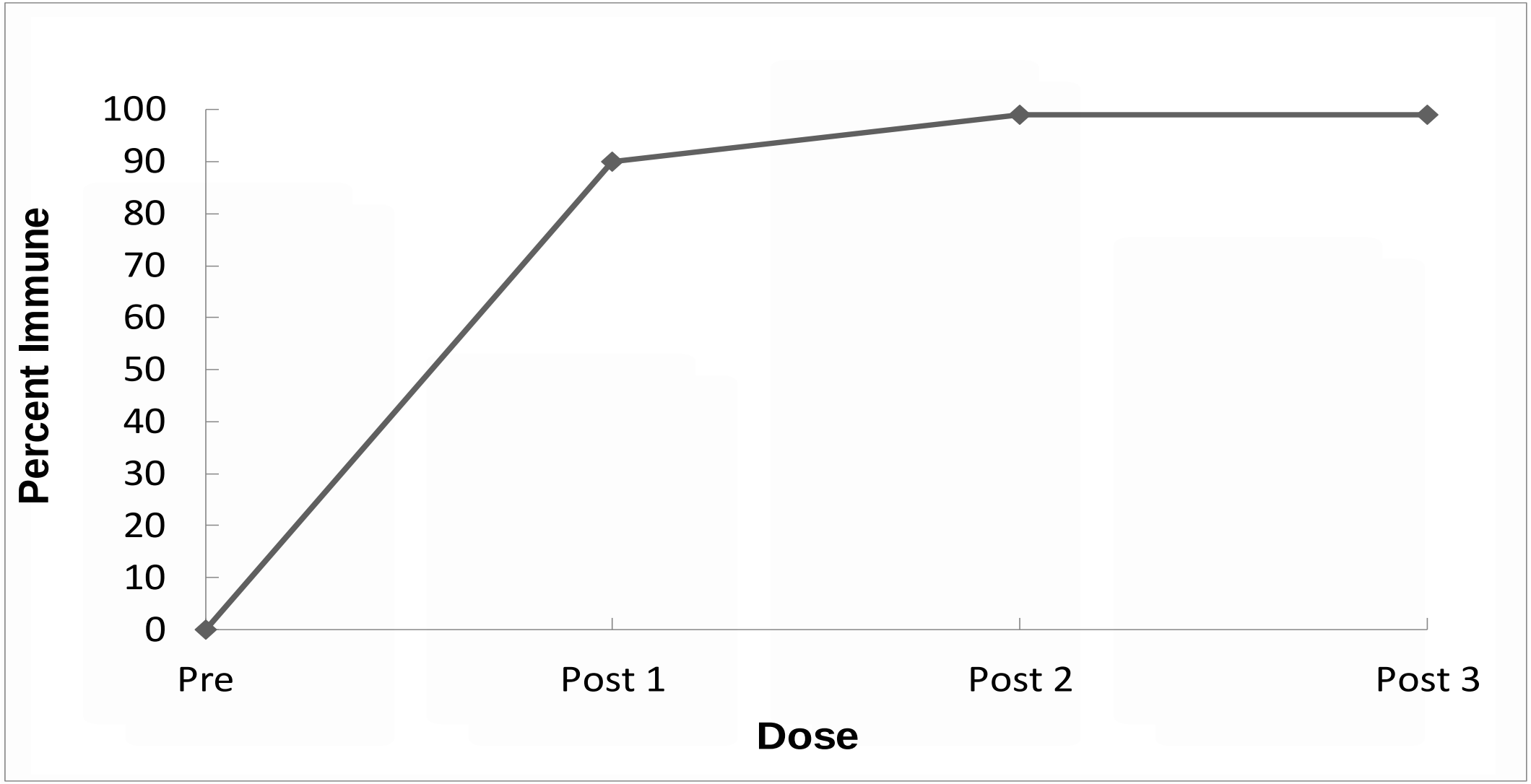
Live Vaccines, cont.

- Severe reactions possible in persons with immune compromise
- Interference from circulating antibody
- Fragile – must be stored and handled carefully

Individual Response to Live Vaccine



Population Response to Live Vaccine



Live, Attenuated Vaccines

- **Viral**

  MMR, varicella, rotavirus, LAIV (intranasal influenza), dengue, yellow fever, oral adenovirus,* oral polio,** Ebola, smallpox***

- **Bacterial**

  BCG,**** oral typhoid, oral cholera

*Live, but not attenuated

**Not used in the United States

***Jynneos vaccine does not replicate and behaves like non-live vaccine

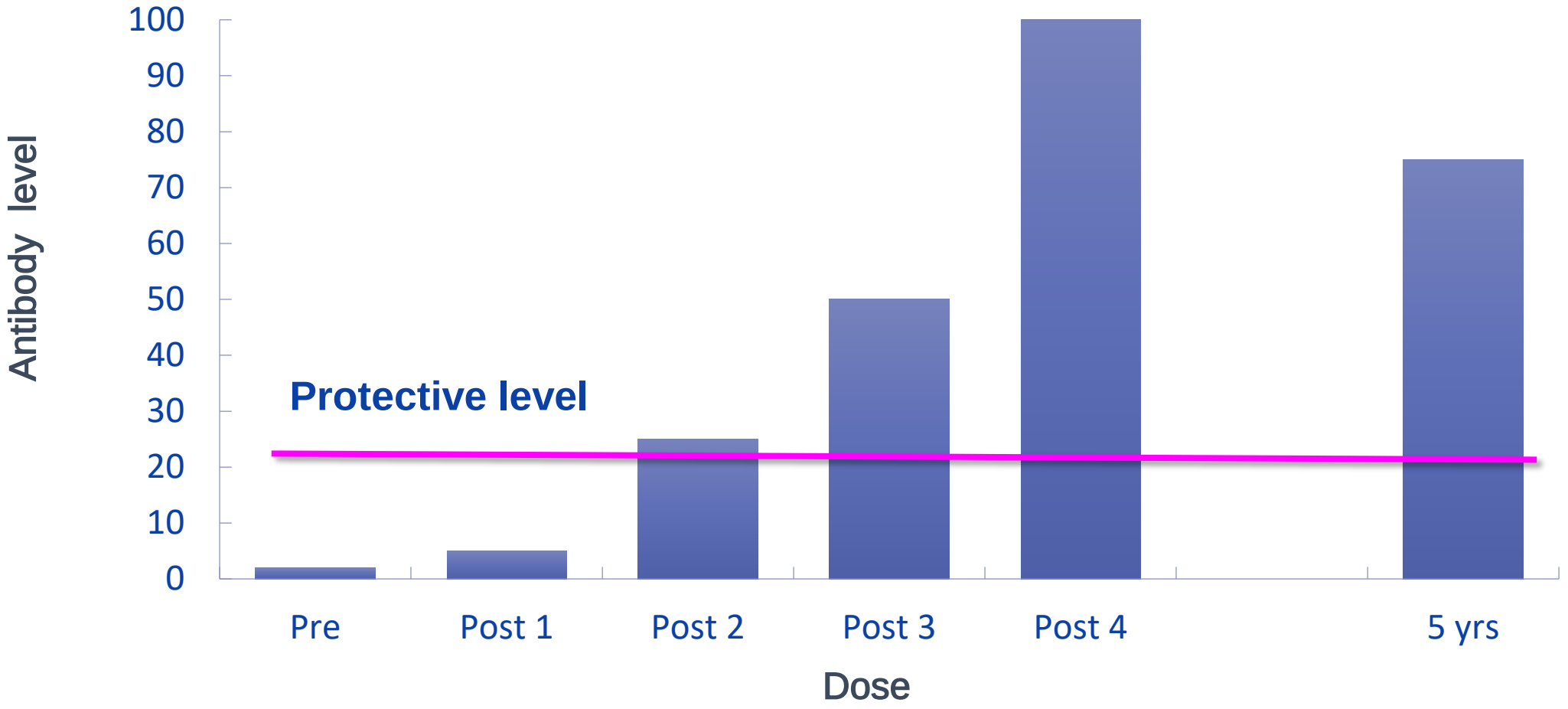
****Not used in the United States for routine TB protection

Live Vaccine Video

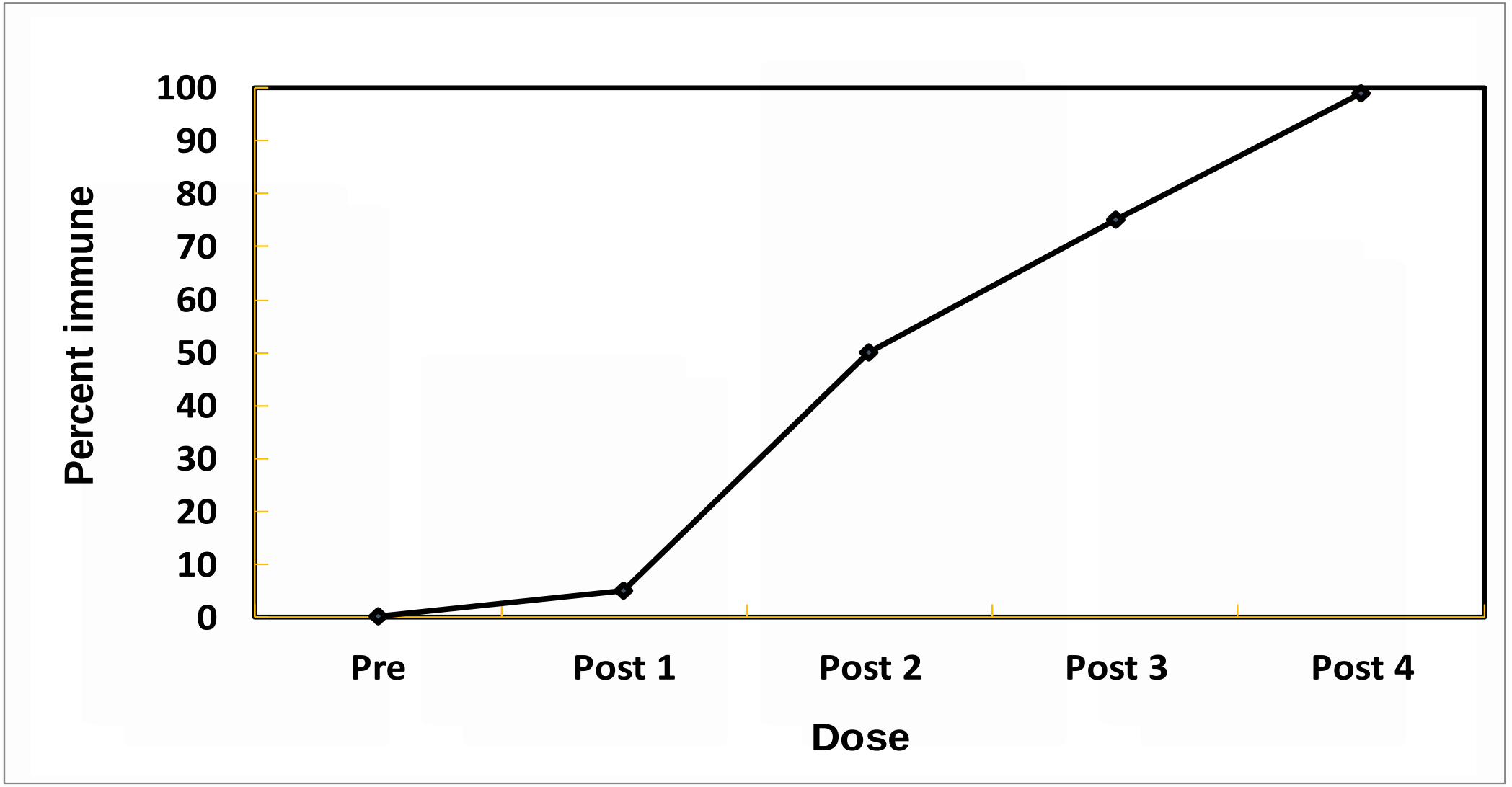
Non-live Vaccines

- Cannot replicate
- Immune response mostly humoral
- Less affected by circulating antibody than live vaccines
- Require multiple doses/periodic supplemental doses
- Antibody titer diminishes with time

Individual Response to Non-live Vaccine



Population Response to Non-live Vaccine



Non-live Vaccines

- **Whole-cell**
  - Polio, hepatitis A, rabies
- **Subunit**
  - Antigens can be protein, polysaccharide, or combination of polysaccharide and protein molecule (i.e., conjugate vaccine)
- **Toxoid**
  - Diphtheria, tetanus
- **Recombinant**
  - Hepatitis B, HPV
- **mRNA**

Non-live Vaccine Video

Knowledge Check

- **Which type of vaccine must replicate to generate an immune response?**

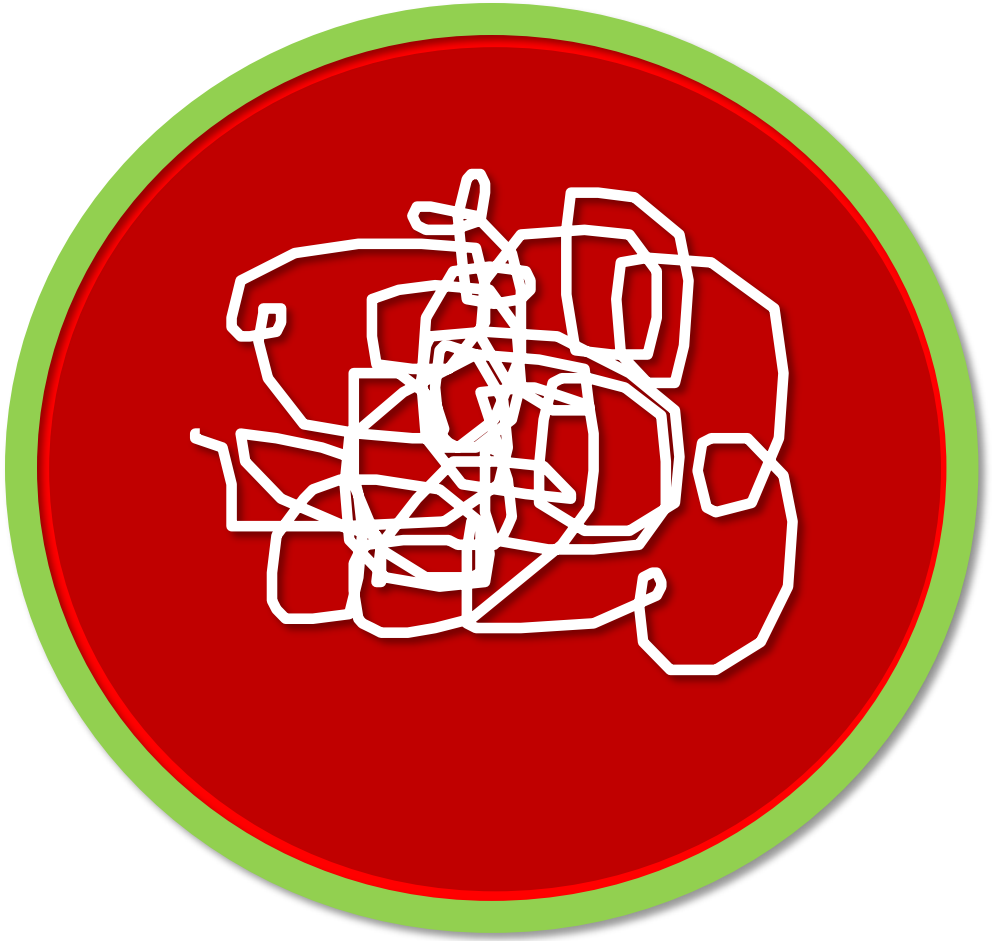
- A. Live vaccine
- B. Non-live vaccine

Answer

- **Which type of vaccine must replicate to generate an immune response?**

- **A. Live vaccine**
- ~~B. Non-live vaccine~~

Capsular Polysaccharide



Pure Polysaccharide Vaccines

- **Immune response typically T-cell-independent**
- **Not consistently immunogenic in children younger than 2 years of age**
- **No booster response**
- **Antibody with less functional activity (IgM rather than IgG)**
- **Immunogenicity improved by conjugation**
  - i.e., combined with a protein

Polysaccharide Vaccines

- **Pure polysaccharide**
  - Pneumococcal (PPSV23)
  - *Salmonella* Typhi (Vi)
- **Conjugate polysaccharide**
  - *Haemophilus influenzae* type b (Hib)
  - Pneumococcal (PCV13, PCV15, PCV20)
  - Meningococcal ACWY

Knowledge Check

- **Which type of polysaccharide vaccine has improved immunogenicity?**

- A. Pure polysaccharide vaccine
- B. Conjugated polysaccharide vaccine

Answer

- **Which type of polysaccharide vaccine has improved immunogenicity?**

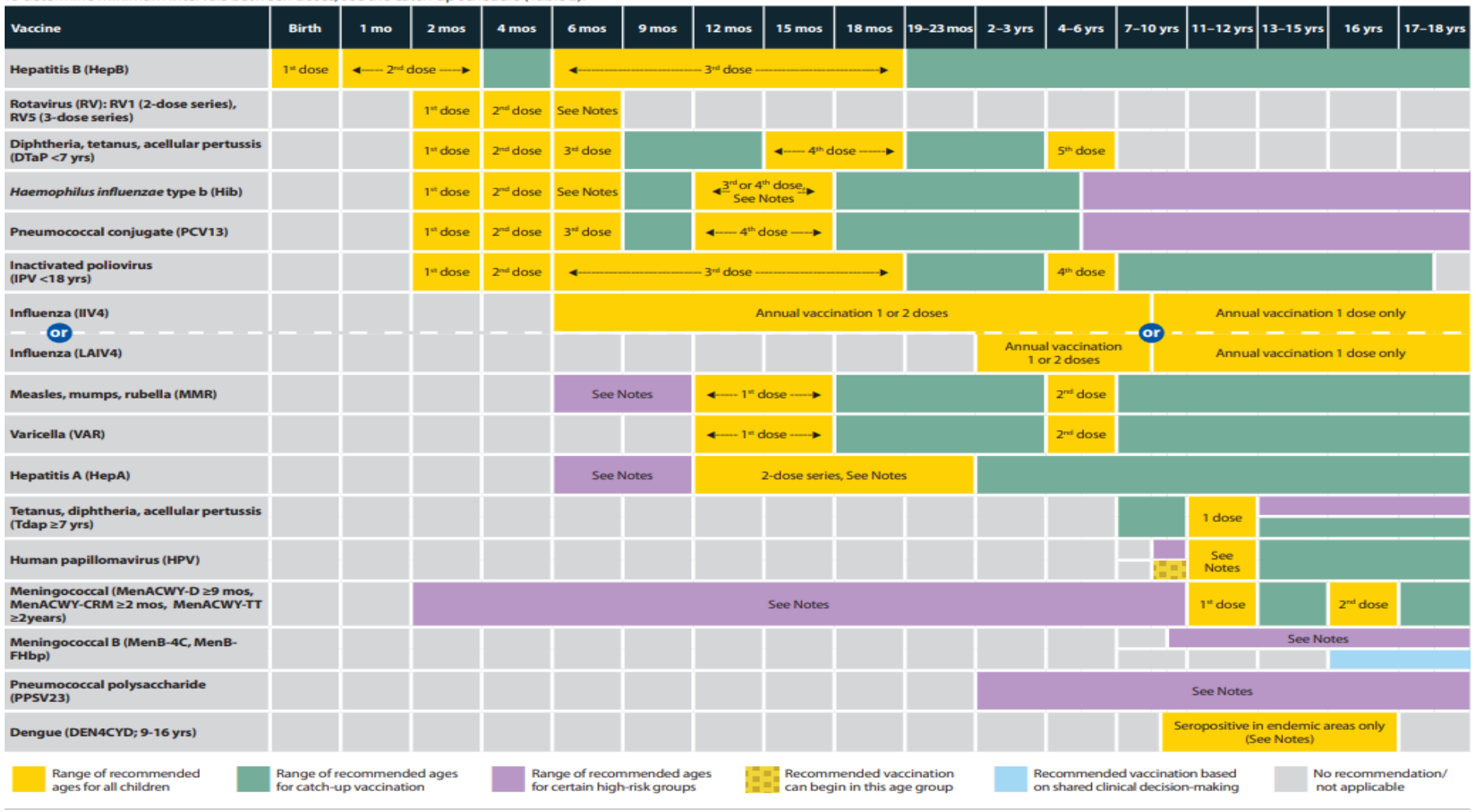
- ~~A. Pure polysaccharide vaccine~~
- **B. Conjugated polysaccharide vaccine**

5

Schedules

Recommended Child and Adolescent Immunization Schedule for Ages 18 Years or Younger, United States, 2022

These recommendations must be read with the notes that follow. For those who fall behind or start late, provide catch-up vaccination at the earliest opportunity as indicated by the green bars.
To determine minimum intervals between doses, see the catch-up schedule (Table 2).



Recommended Catch-up Immunization Schedule for Children and Adolescents Who Start Late or Who Are More than 1 Month Behind, United States, 2022

The table below provides catch-up schedules and minimum intervals between doses for children whose vaccinations have been delayed. A vaccine series does not need to be restarted, regardless of the time that has elapsed between doses. Use the section appropriate for the child's age. **Always use this table in conjunction with Table 1 and the Notes that follow.**

Vaccine	Minimum Age for Dose 1	Minimum Interval Between Doses			
		Dose 1 to Dose 2	Dose 2 to Dose 3	Dose 3 to Dose 4	Dose 4 to Dose 5
Children age 4 months through 6 years					
Hepatitis B	Birth	**4 weeks**	**8 weeks *and* at least 16 weeks after first dose** minimum age for the final dose is 24 weeks		
Rotavirus	6 weeks Maximum age for first dose is 14 weeks, 6 days.	**4 weeks**	**4 weeks** maximum age for final dose is 8 months, 0 days		
Diphtheria, tetanus, and acellular pertussis	6 weeks	**4 weeks**	**4 weeks**	**6 months**	**6 months**
Haemophilus influenzae type b	6 weeks	**No further doses needed** if first dose was administered at age 15 months or older. **4 weeks** if first dose was administered before the 1st birthday. **8 weeks (as final dose)** if first dose was administered at age 12 through 14 months.	**No further doses needed** if previous dose was administered at age 15 months or older **4 weeks** if current age is younger than 12 months ***and*** first dose was administered at younger than age 7 months ***and*** at least 1 previous dose was PRP-T (ActHib®, Pentacel®, Hiberix®), Vaxelis® or unknown **8 weeks *and* age 12 through 59 months (as final dose)** if current age is younger than 12 months ***and*** first dose was administered at age 7 through 11 months; OR if current age is 12 through 59 months ***and*** first dose was administered before the 1st birthday ***and*** second dose was administered at younger than 15 months; OR if both doses were PedvaxHIB® and were administered before the 1st birthday	**8 weeks (as final dose)** This dose only necessary for children age 12 through 59 months who received 3 doses before the 1st birthday.	
Pneumococcal conjugate	6 weeks	**No further doses needed** for healthy children if first dose was administered at age 24 months or older **4 weeks** if first dose was administered before the 1st birthday **8 weeks (as final dose for healthy children)** if first dose was administered at the 1st birthday or after	**No further doses needed** for healthy children if previous dose was administered at age 24 months or older **4 weeks** if current age is younger than 12 months and previous dose was administered at <7 months old **8 weeks (as final dose for healthy children)** if previous dose was administered between 7–11 months (wait until at least 12 months old); OR if current age is 12 months or older and at least 1 dose was administered before age 12 months	**8 weeks (as final dose)** This dose only necessary for children age 12 through 59 months who received 3 doses before age 12 months or for children at high risk who received 3 doses at any age.	
Inactivated poliovirus	6 weeks	**4 weeks**	**4 weeks** if current age is <4 years **6 months (as final dose)** if current age is 4 years or older	**6 months (minimum age 4 years for final dose)**	
Measles, mumps, rubella	12 months	**4 weeks**			
Varicella	12 months	**3 months**			
Hepatitis A	12 months	**6 months**			
Meningococcal ACWY	2 months MenACWY-CRM 9 months MenACWY-D 2 years MenACWY-TT	**8 weeks**	See Notes	See Notes	
Children and adolescents age 7 through 18 years					
Meningococcal ACWY	Not applicable (N/A)	**8 weeks**			
Tetanus, diphtheria; tetanus, diphtheria, and acellular pertussis	7 years	**4 weeks**	**4 weeks** if first dose of DTaP/DT was administered before the 1st birthday **6 months (as final dose)** if first dose of DTaP/DT or Tdap/Td was administered at or after the 1st birthday	**6 months** if first dose of DTaP/DT was administered before the 1st birthday	
Human papillomavirus	9 years	**Routine dosing intervals are recommended.**			
Hepatitis A	N/A	**6 months**			
Hepatitis B	N/A	**4 weeks**	**8 weeks *and* at least 16 weeks after first dose**		
Inactivated poliovirus	N/A	**4 weeks**	**6 months** A fourth dose is not necessary if the third dose was administered at age 4 years or older and at least 6 months after the previous dose.	A fourth dose of IPV is indicated if all previous doses were administered at <4 years or if the third dose was administered <6 months after the second dose.	
Measles, mumps, rubella	N/A	**4 weeks**			
Varicella	N/A	**3 months** if younger than age 13 years. **4 weeks** if age 13 years or older			
Dengue	9 years	**6 months**	6 months		

Recommended Child and Adolescent Immunization Schedule by Medical Indication, United States, 2022

Always use this table in conjunction with Table 1 and the Notes that follow.

VACCINE	INDICATION										
			HIV infection CD4+ count[1]								
	Pregnancy	Immunocompromised status (excluding HIV infection)	<15% or total CD4 cell count of <200/mm³	≥15% and total CD4 cell count of ≥200/mm³	Kidney failure, end-stage renal disease, or on hemodialysis	Heart disease or chronic lung disease	CSF leak or cochlear implant	Asplenia or persistent complement component deficiencies	Chronic liver disease	Diabetes
Hepatitis B										
Rotavirus		SCID[2]								
Diphtheria, tetanus, and acellular pertussis (DTaP)										
Haemophilus influenzae type b										
Pneumococcal conjugate										
Inactivated poliovirus										
Influenza (IIV4)										
or										
Influenza (LAIV4)						Asthma, wheezing: 2–4yrs[3]				
Measles, mumps, rubella	*									
Varicella	*									
Hepatitis A										
Tetanus, diphtheria, and acellular pertussis (Tdap)										
Human papillomavirus	*									
Meningococcal ACWY										
Meningococcal B										
Pneumococcal polysaccharide										
Dengue										

Vaccination according to the routine schedule recommended

Recommended for persons with an additional risk factor for which the vaccine would be indicated

Vaccination is recommended, and additional doses may be necessary based on medical condition or vaccine. See Notes.

Precaution—vaccine might be indicated if benefit of protection outweighs risk of adverse reaction

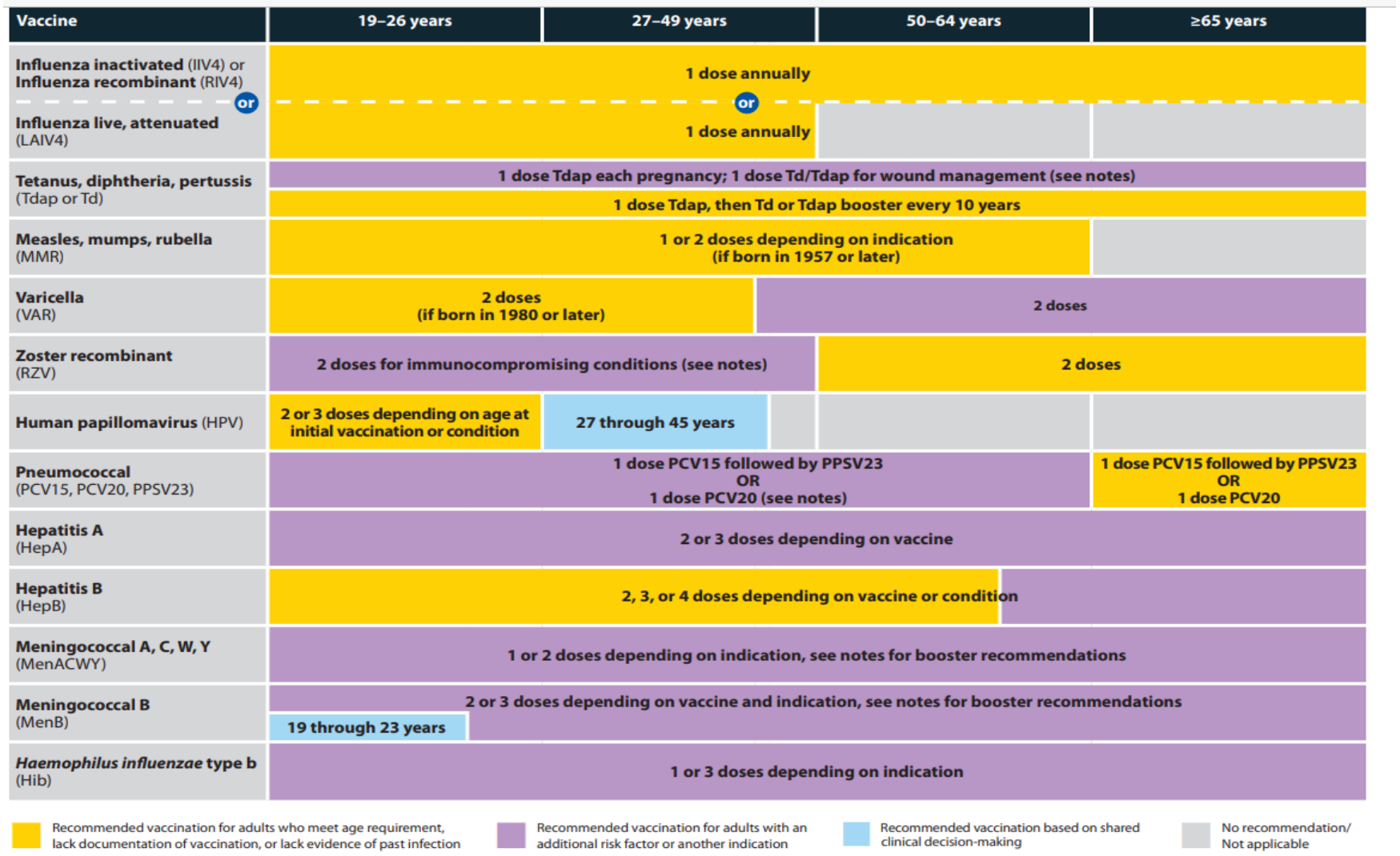
Contraindicated or not recommended—vaccine should not be administered

*Vaccinate after pregnancy

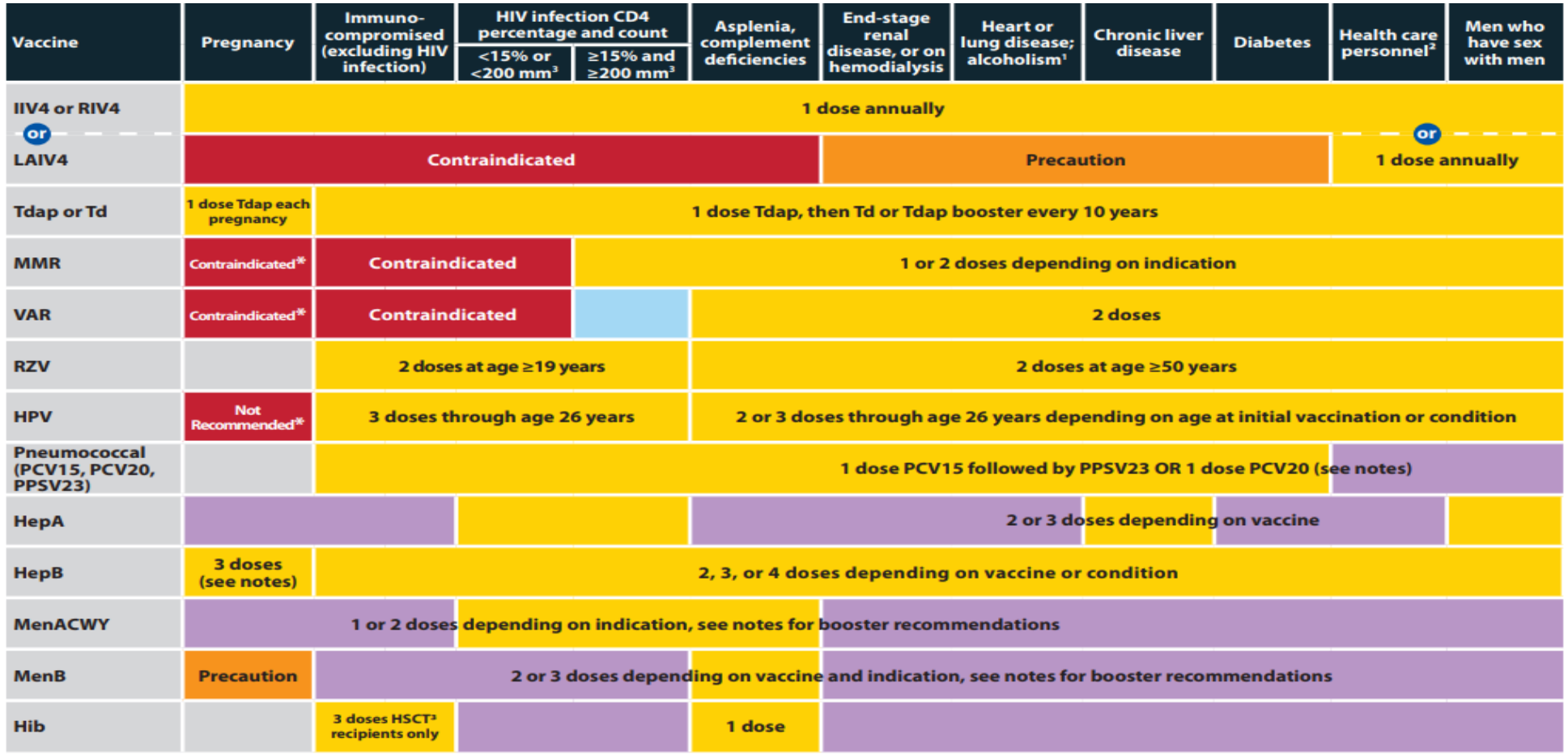
No recommendation/not applicable

1 For additional information regarding HIV laboratory parameters and use of live vaccines, see the *General Best Practice Guidelines for Immunization*, "Altered Immunocompetence," at www.cdc.gov/vaccines/hcp/acip-recs/general-recs/immunocompetence.html and Table 4-1 (footnote J) at www.cdc.gov/vaccines/hcp/acip-recs/general-recs/contraindications.html.
2 Severe Combined Immunodeficiency
3 LAIV4 contraindicated for children 2–4 years of age with asthma or wheezing during the preceding 12 months

Recommended Adult Immunization Schedule by Age Group, United States, 2022



Recommended Adult Immunization Schedule by Medical Condition or Other Indication, United States, 2022



1. Precaution for LAIV4 does not apply to alcoholism. **2.** See notes for influenza; hepatitis B; measles, mumps, and rubella; and varicella vaccinations. **3.** Hematopoietic stem cell transplant.

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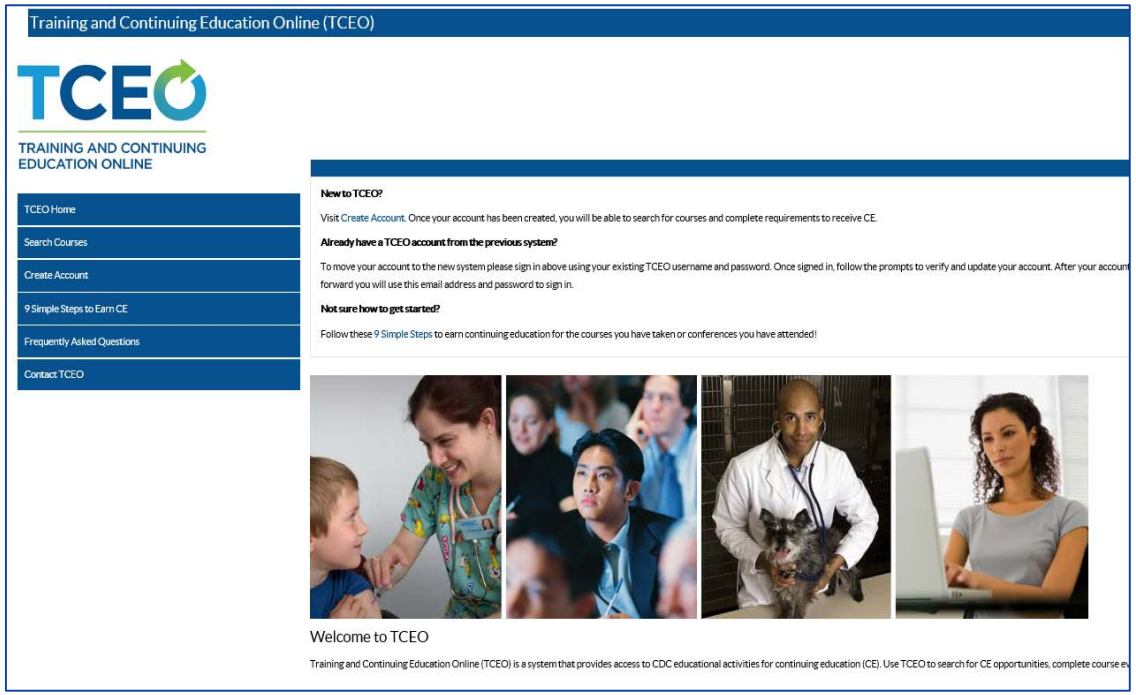

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Thank You From Atlanta!