Principles of Vaccination

Pink Book Webinar Series
Chapter 1
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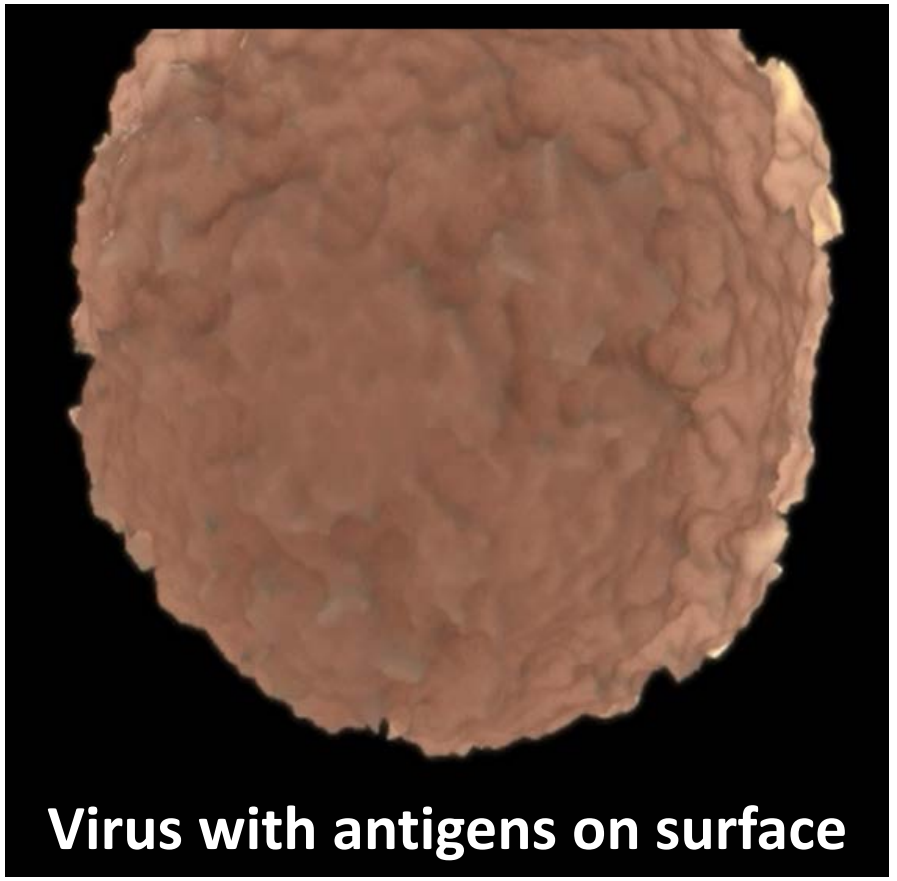
Immunity

Immunity

- Self vs. “nonself”
- Protection from infectious diseases
- Usually indicated by the presence of antibody
- Generally specific to a single organism

Antigen

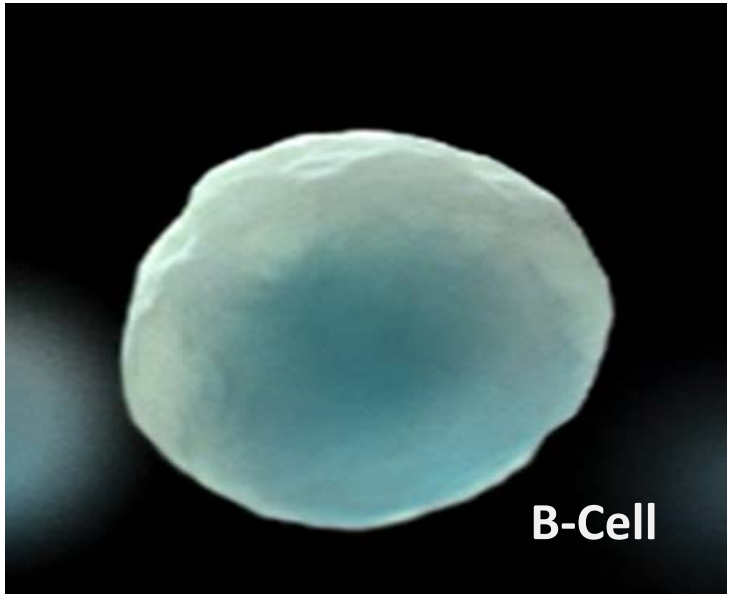
- Live or inactivated substances (e.g., viruses, bacteria, toxins)
  - Capable of stimulating an immune response
- Antigen = antibody generator

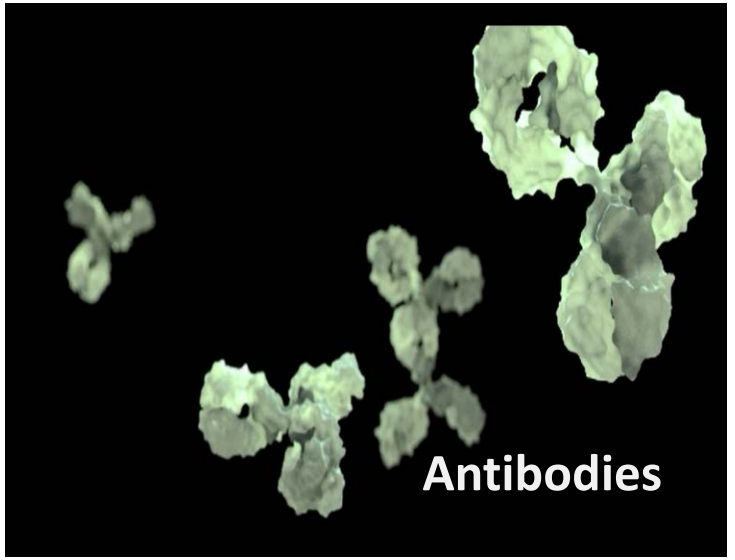


Virus with antigens on surface

Antibody

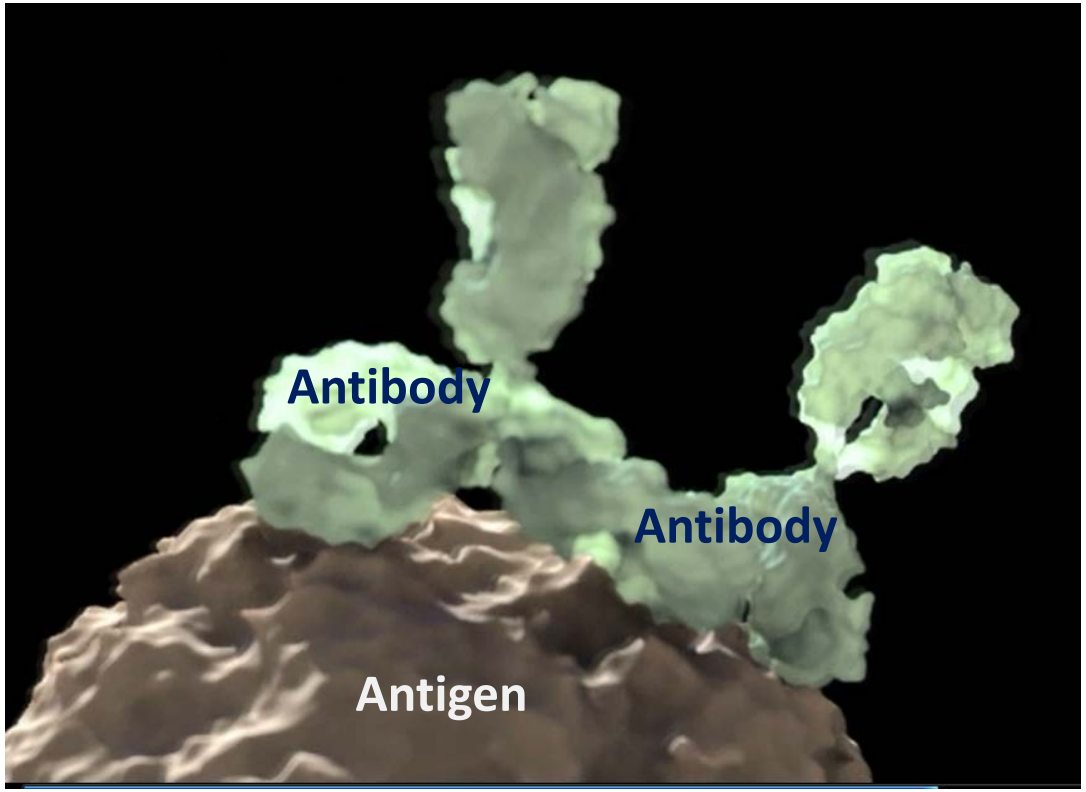
- Protein molecules (immunoglobulins)
  - Produced by B cells (lymphocytes) to bind to a corresponding antigen (lock and key mechanism)
  - Helps neutralize antigen and prepare it for destruction
  - B cells develop in the bone marrow





Arms of the Immune System

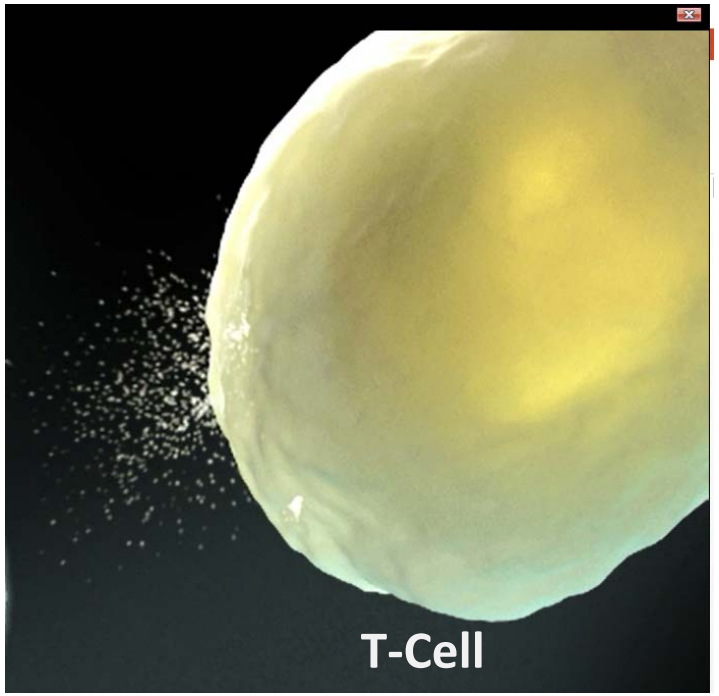
- Humoral
  - Production of antibodies that are specific to a certain antigen or group of antigens
  - Antibodies attach to invading organism and interfere with its ability to produce more invading organisms



Antibodies attaching to antigens

Arms of the Immune System

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



Types of Immunity: Active and Passive

Passive Immunity

- Transfer of antibody produced by one human or animal to another
- Temporary protection that wanes with time
- Transfer of antibody through placenta – important to protect infants

Passive Immunity Video

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 American adult donors

  - Hepatitis A and measles postexposure prophylaxis (PEP)

Sources of Passive Immunity

- Homologous human hyperimmune globulin (e.g., HBIG)
  - Taken 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

- Monoclonal antibodies
  - Derived from a single type, or clone, of antibody-producing cells (B cells)
    - Immune globulin from human sources is polyclonal (contains many different 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

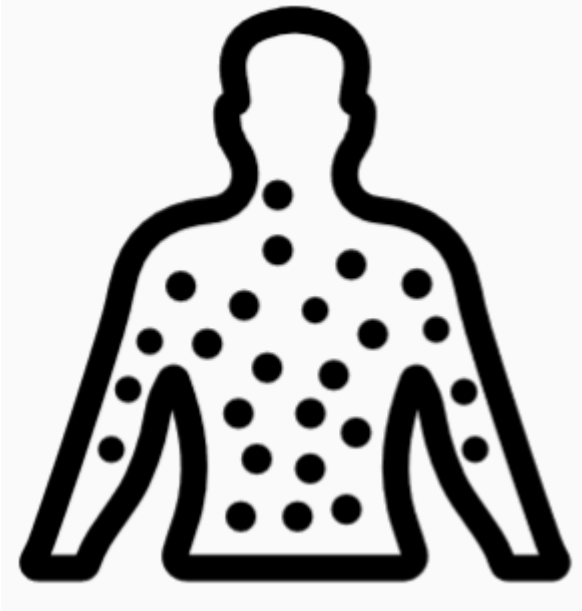
Active Immunity

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

Active Immunity Video

Sources of Active Immunity

- Infection with disease-causing form of organism



- Vaccination

Vaccination

- Active immunity produced by vaccine
  - Vaccine delivers a dead or attenuated (weakened, nonpathogenic) 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

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
- Vaccinee
  - Age
  - Nutritional status
  - Genetics
  - Coexisting disease

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Classification of Vaccines

Classification of Vaccines

- Live, attenuated (weakened form of the organism)
  - Viral or bacterial
- Inactivated (nonlive or fraction of the organism)
  - Viral or bacterial
  - Protein-based (e.g., toxoid or subunit vaccines)
  - Polysaccharide based (e.g., bacterial cell wall polysaccharide)

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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

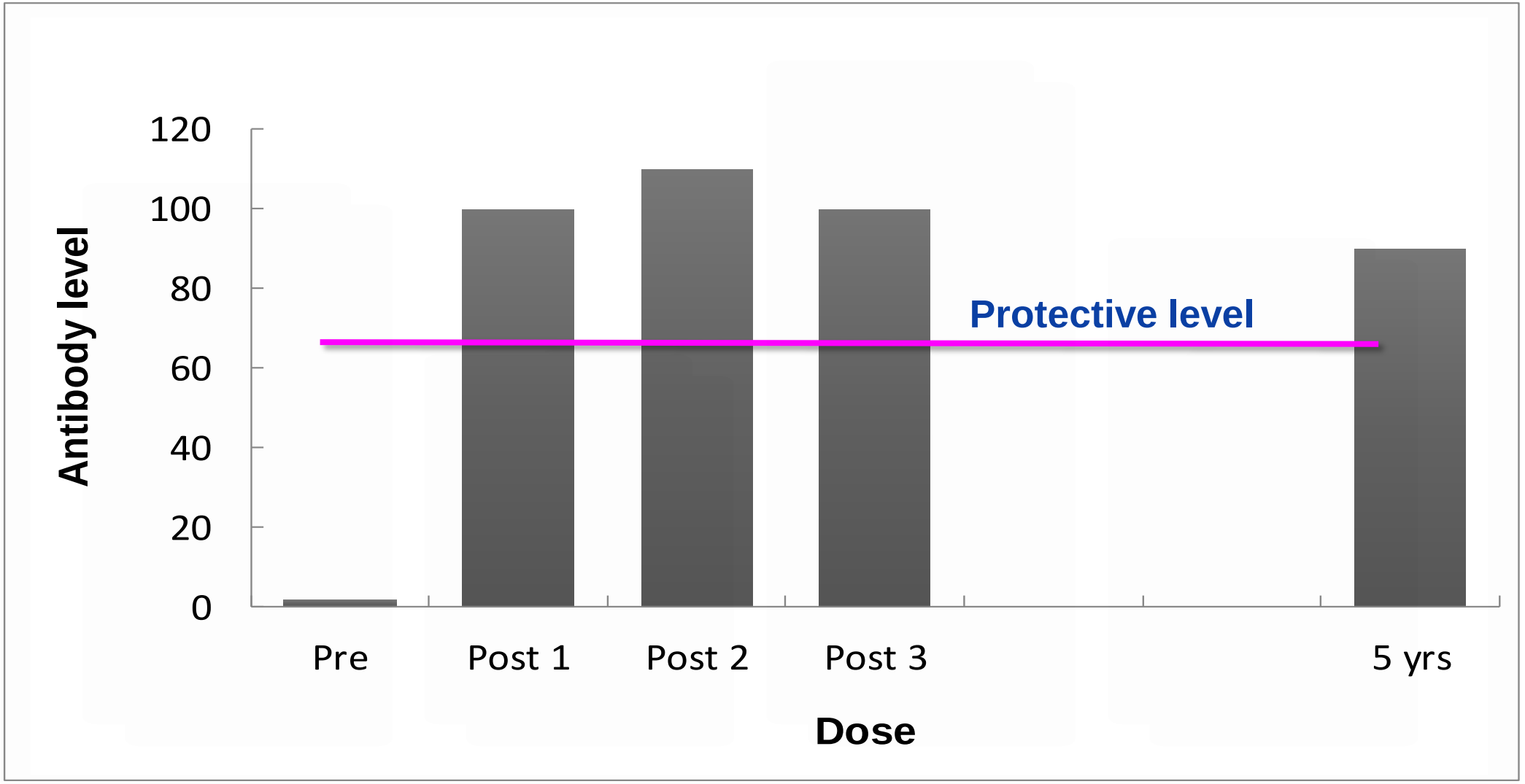
Live Attenuated Vaccine Vidoe

Live, Attenuated Vaccines

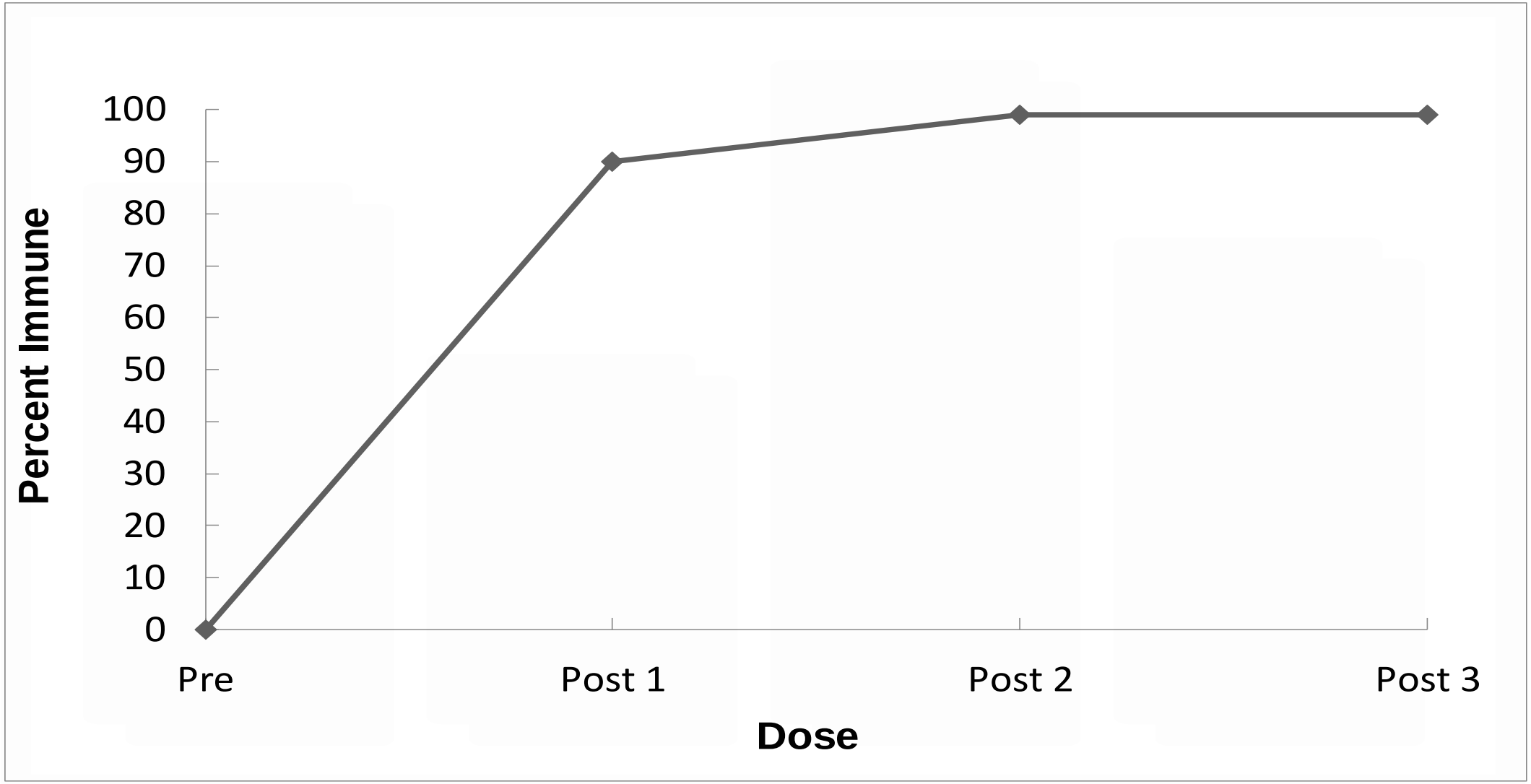
- Attenuated (weakened) form of the "wild" virus or bacterium
- Must replicate to produce an immune response
- Immune response virtually identical to natural infection
- Usually produce immunity with 1 dose*

*Except those administered orally

Individual Response to Live Vaccine

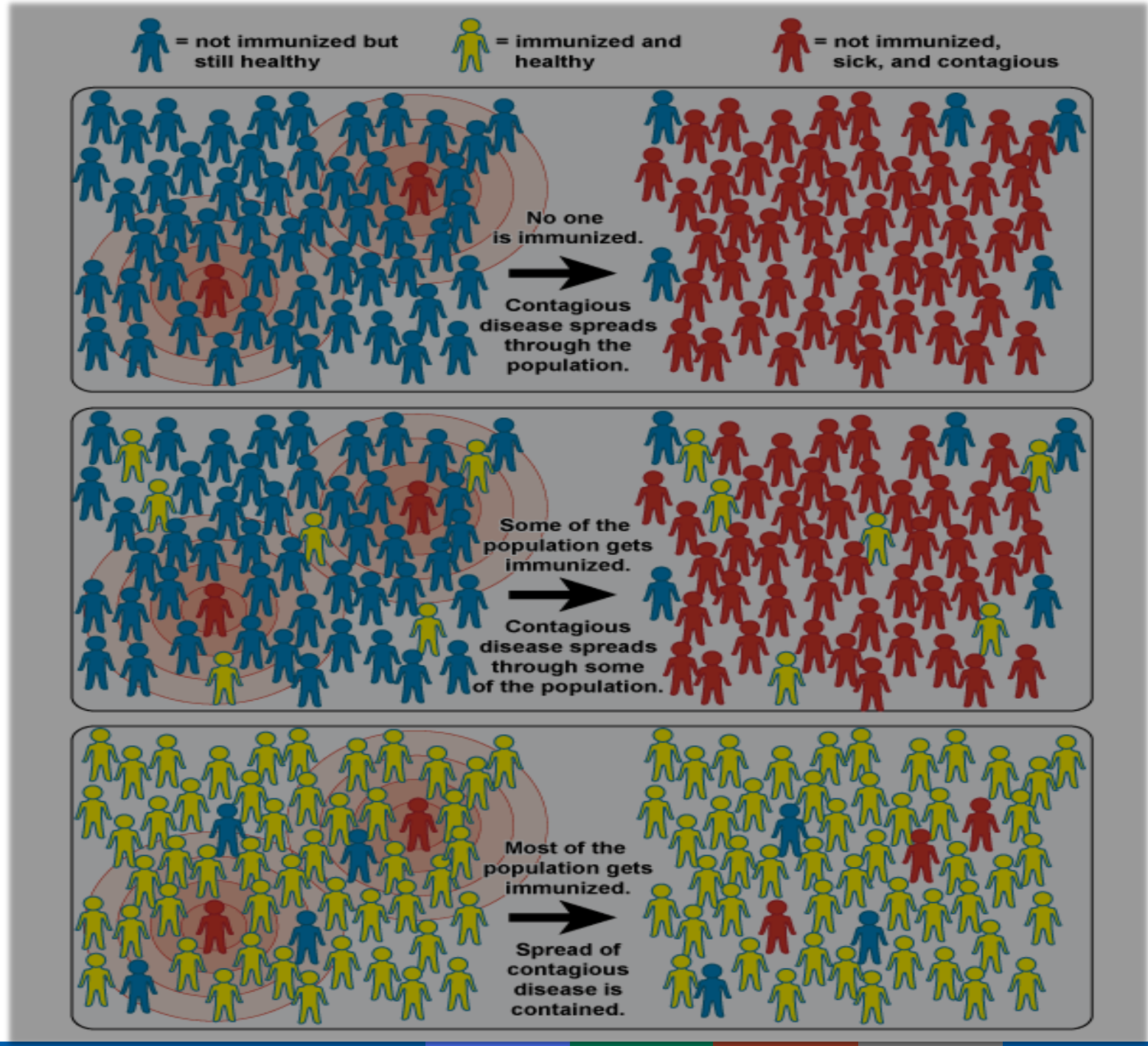


Population Response to Live Vaccine



Herd Immunity/ Community Immunity

- When a significant portion of the population is immune and provides protection for individuals who are not immune



Live, Attenuated Vaccines

- Severe reactions possible
- Interference from circulating antibody
- Fragile – must be stored and handled carefully

Live, Attenuated Vaccines

- Viral

  MMR, varicella, zoster vaccine live (ZVL), yellow fever, rotavirus, LAIV (intranasal influenza), smallpox (vaccinia), oral adenovirus, oral polio*

- Bacterial

  BCG,** oral typhoid, oral cholera

* Not used in the United States

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

Inactivated Vaccines

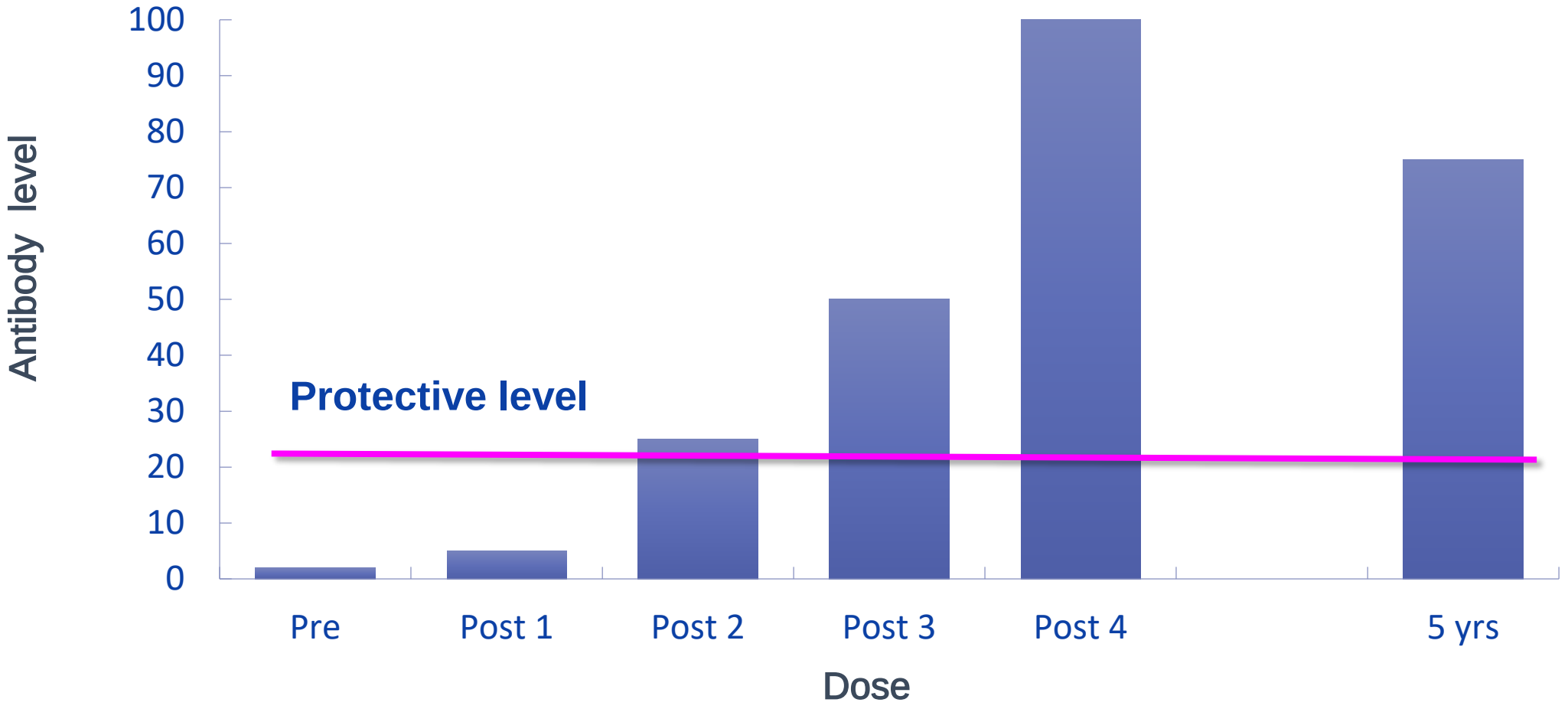
- Whole
  - Viruses
  - Bacteria
- Fractional
  - Protein-based
    - Toxoid
    - Subunit
  - Polysaccharide-based
    - Pure
    - Conjugate

Inactivated Vaccine Video

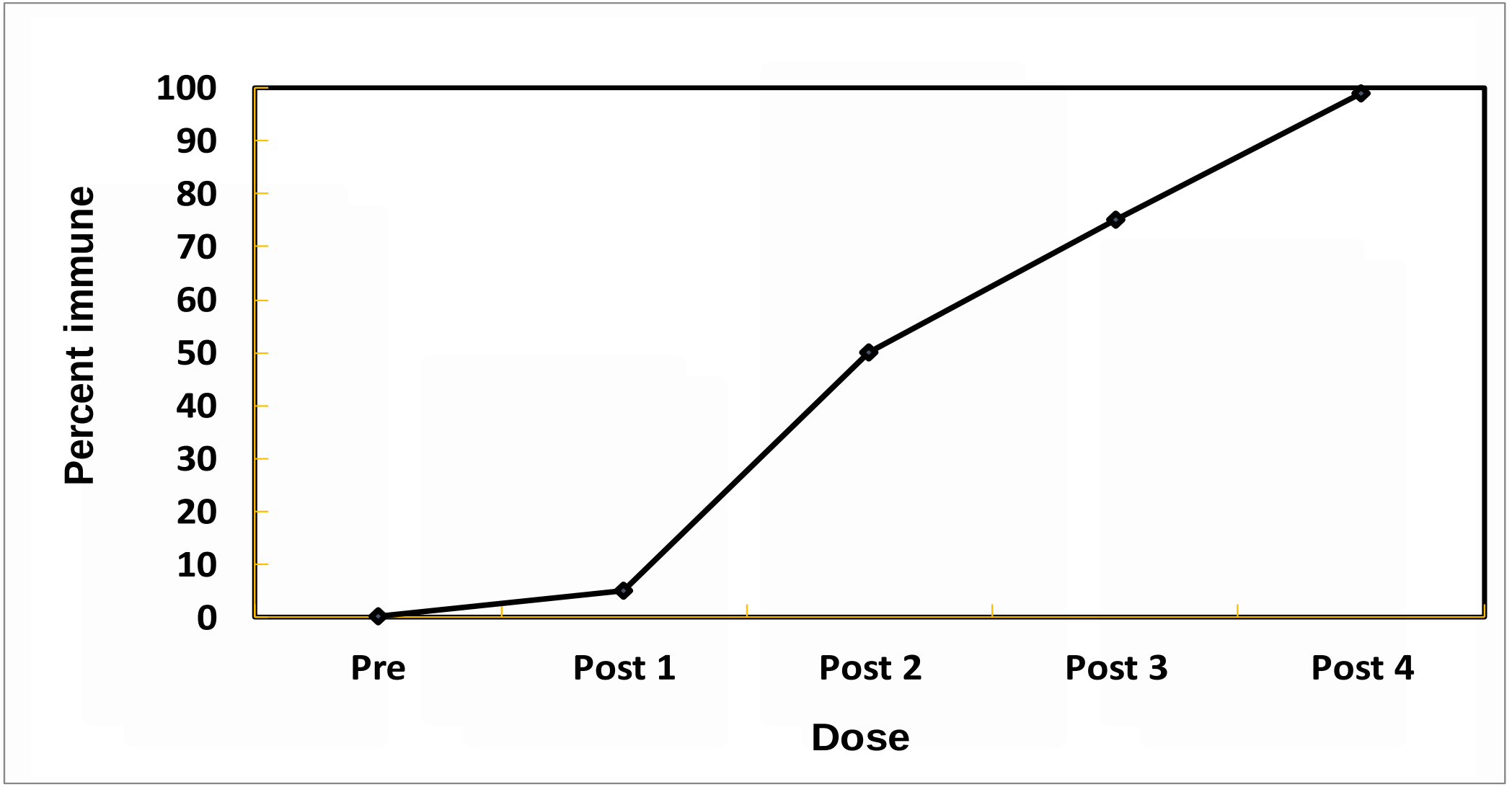
Inactivated Vaccines

- Cannot replicate
- Less affected by circulating antibody than live vaccines
  - Example: HepB vaccine and HBIG for perinatal hepatitis B PEP
- Always require multiple doses
- Immune response mostly humoral
- Antibody titer diminishes with time
- May require periodic supplemental doses

Individual Response to Inactivated Vaccine



Population Response to Inactivated Vaccine



Inactivated Vaccines

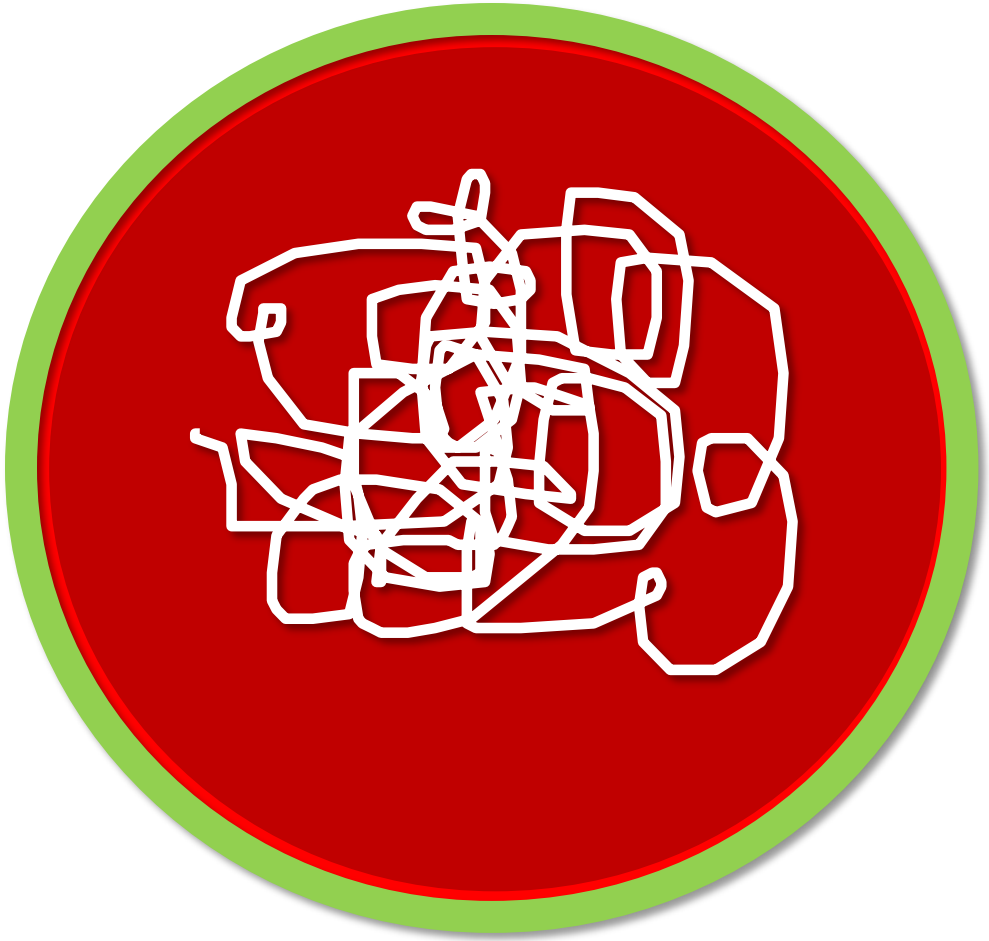
- Whole
  - Viral
    - Polio, hepatitis A, rabies, Japanese encephalitis, and influenza*
  - Bacterial
    - Pertussis,* typhoid,* cholera,* plague*

*Not available in the United States

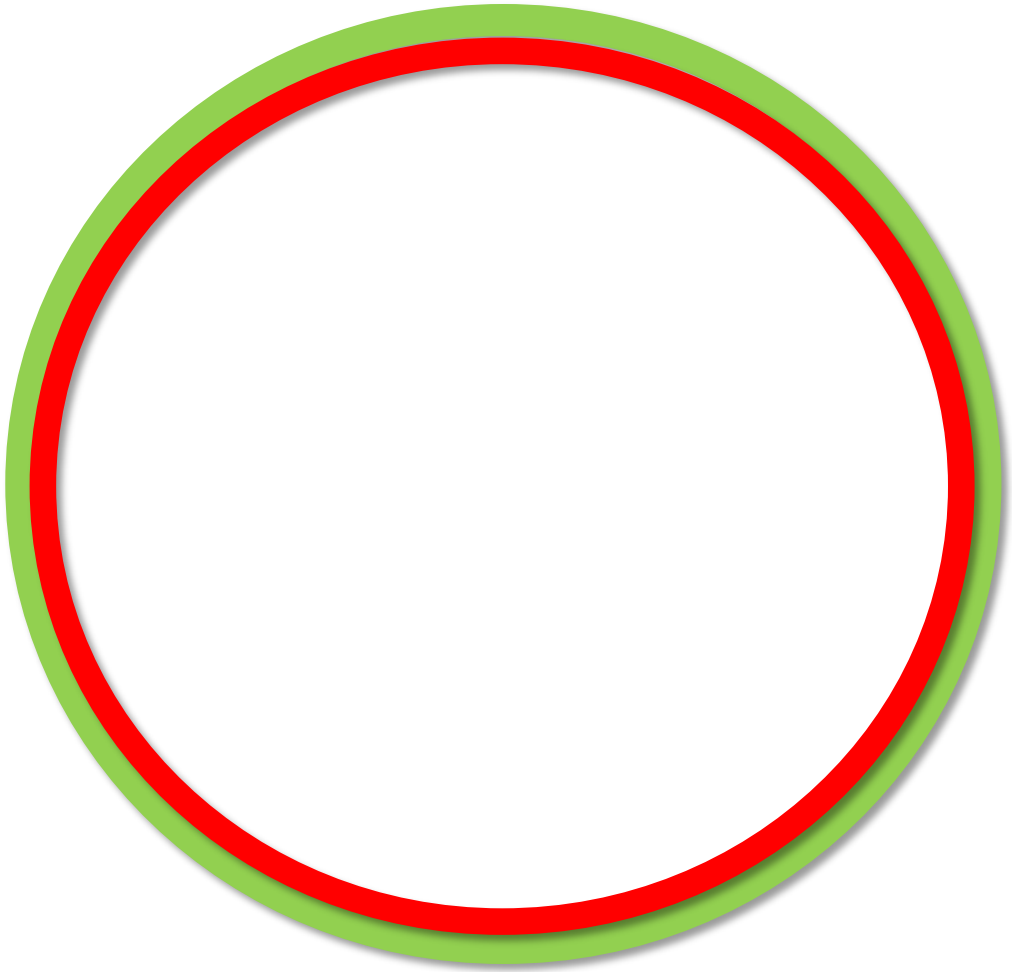
Inactivated Vaccines

- Fractional
  - Subunit
    - Hepatitis B, influenza, acellular pertussis, human papillomavirus, and anthrax
    - Polysaccharide vaccines
  - Toxoid
    - Diphtheria, tetanus

Capsular Polysaccharide



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

Polysaccharide Vaccines

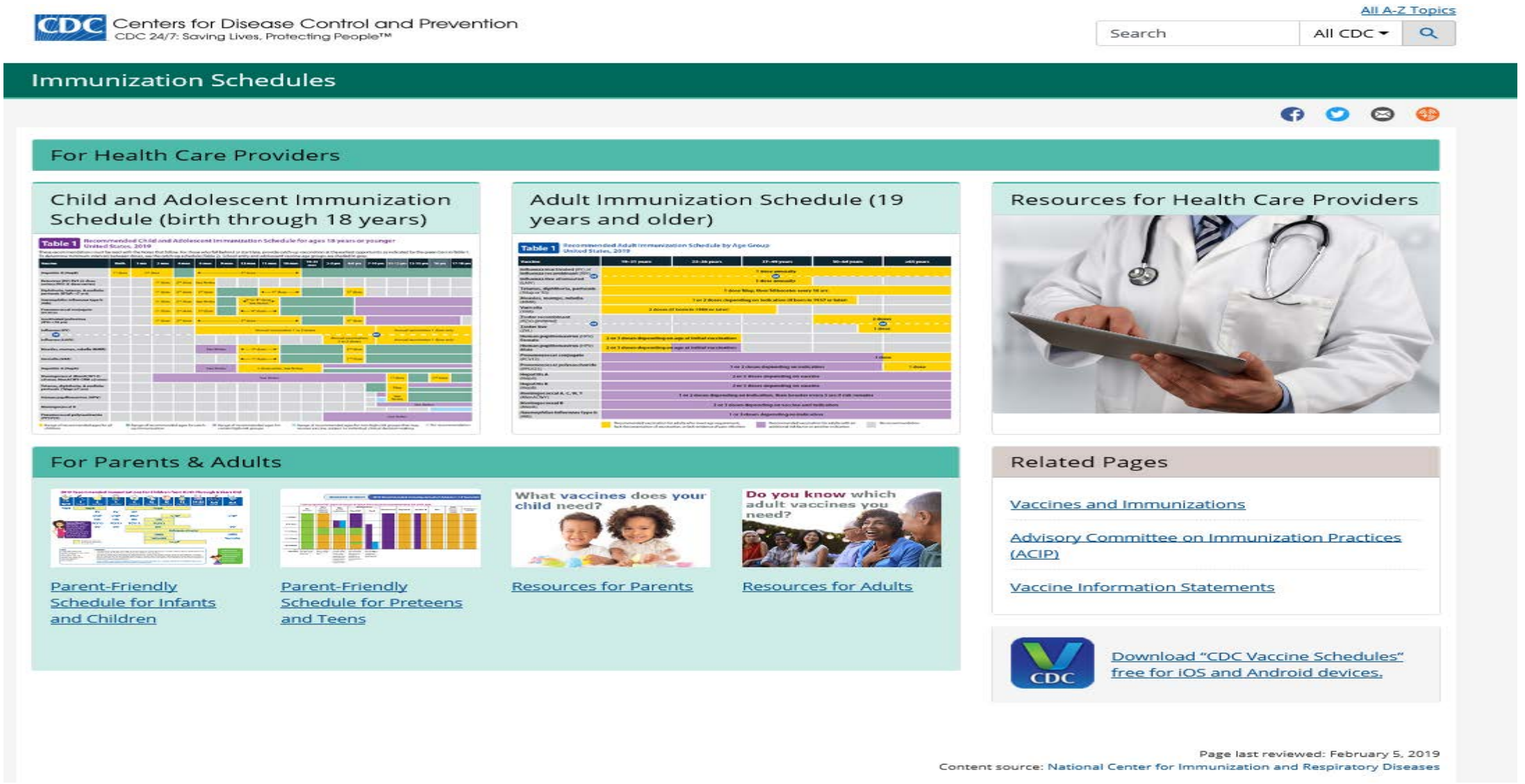
- Pure polysaccharide
  - Pneumococcal (PPSV23)
  - *Salmonella* Typhi (Vi)
- Conjugate polysaccharide
  - *Haemophilus influenzae* type b (Hib)
  - Pneumococcal (PCV13)
  - Meningococcal

Genetically Engineered Vaccines

- Viral: hepatitis B, human papillomavirus, influenza (RIV), influenza (LAIV), and rotavirus (RV5)

- Bacterial: meningococcal B

New Design for Schedule Web Pages



Recommended Immunization Schedules for Health Care Providers www.cdc.gov/vaccines/schedules/index.html Accessed 5/31/2019

Table 1 Recommended Child and Adolescent Immunization Schedule for ages 18 years or younger United States, 2019

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 in Table 1. To determine minimum intervals between doses, see the catch-up schedule (Table 2). School entry and adolescent vaccine age groups are shaded in gray.

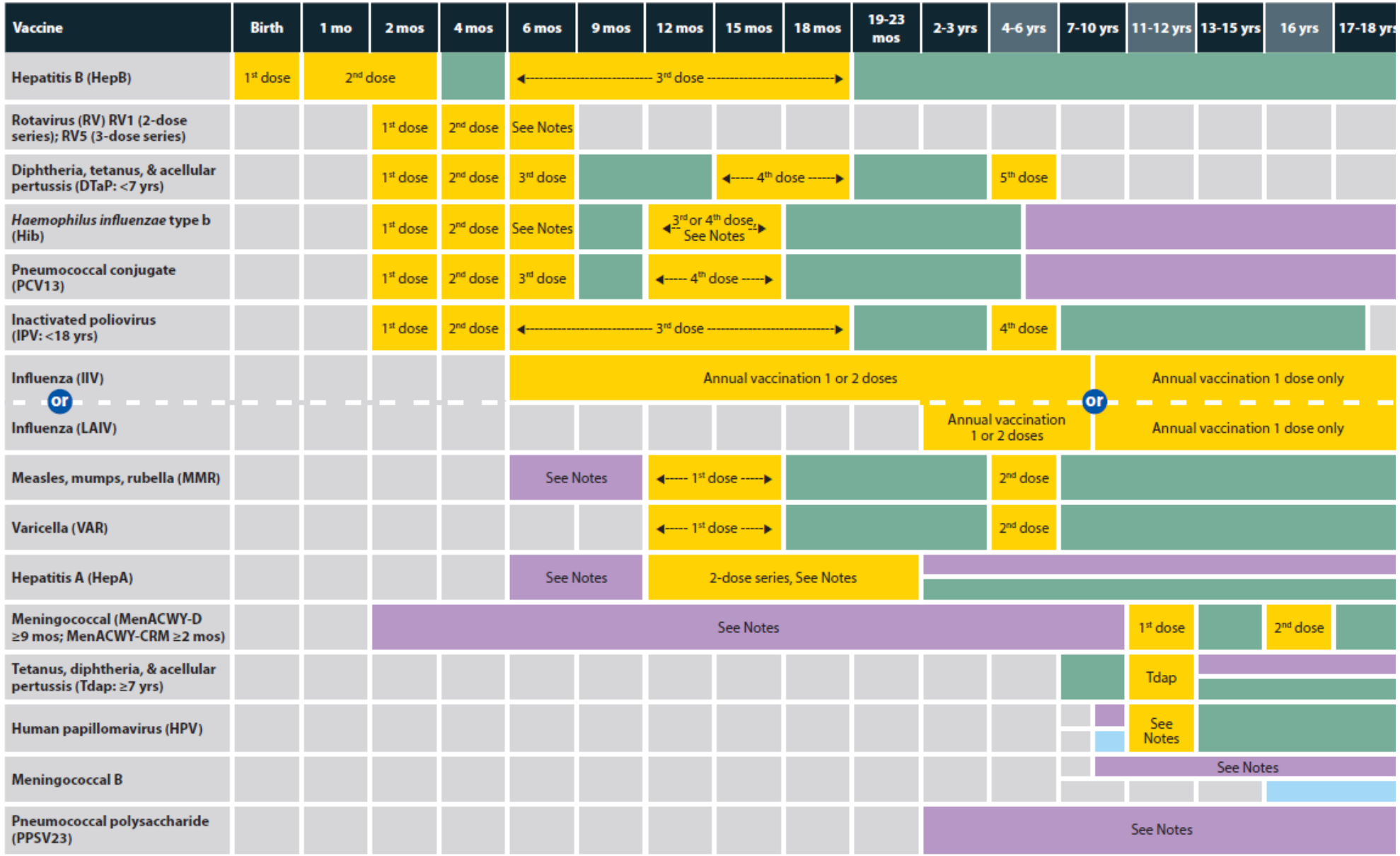


Table 2 Catch-up immunization schedule for persons aged 4 months—18 years who start late or who are more than 1 month behind, United States, 2019

The figure 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) 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 administered at younger than 15 months; OR if both doses were PRP-OMP (PedvaxHIB; Comvax) ***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 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 administered at age 24 months or older. **4 weeks** if current age is younger than 12 months and previous dose given at <7 months old. **8 weeks (as final dose for healthy children)** if previous dose given 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 given 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	2 months MenACWY-CRM 9 months MenACWY-D	**8 weeks**	See Notes	See Notes	
Children and adolescents age 7 through 18 years					
Meningococcal	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	

Table 3 Recommended Child and Adolescent Immunization Schedule by Medical Indication United States, 2019

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

- 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. See Notes.
- Contraindicated or use not recommended—vaccine should not be administered because of risk for serious adverse reaction
- Precaution—vaccine might be indicated if benefit of protection outweighs risk of adverse reaction
- Delay vaccination until after pregnancy if vaccine indicated
- No recommendation

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 D) at: www.cdc.gov/vaccines/hcp/acip-recs/general-recs/contraindications.html.

2 Severe Combined Immunodeficiency

3 LAIV contraindicated for children 2–4 years of age with asthma or wheezing during the preceding 12 months.

Table 1 Recommended Adult Immunization Schedule by Age Group United States, 2019

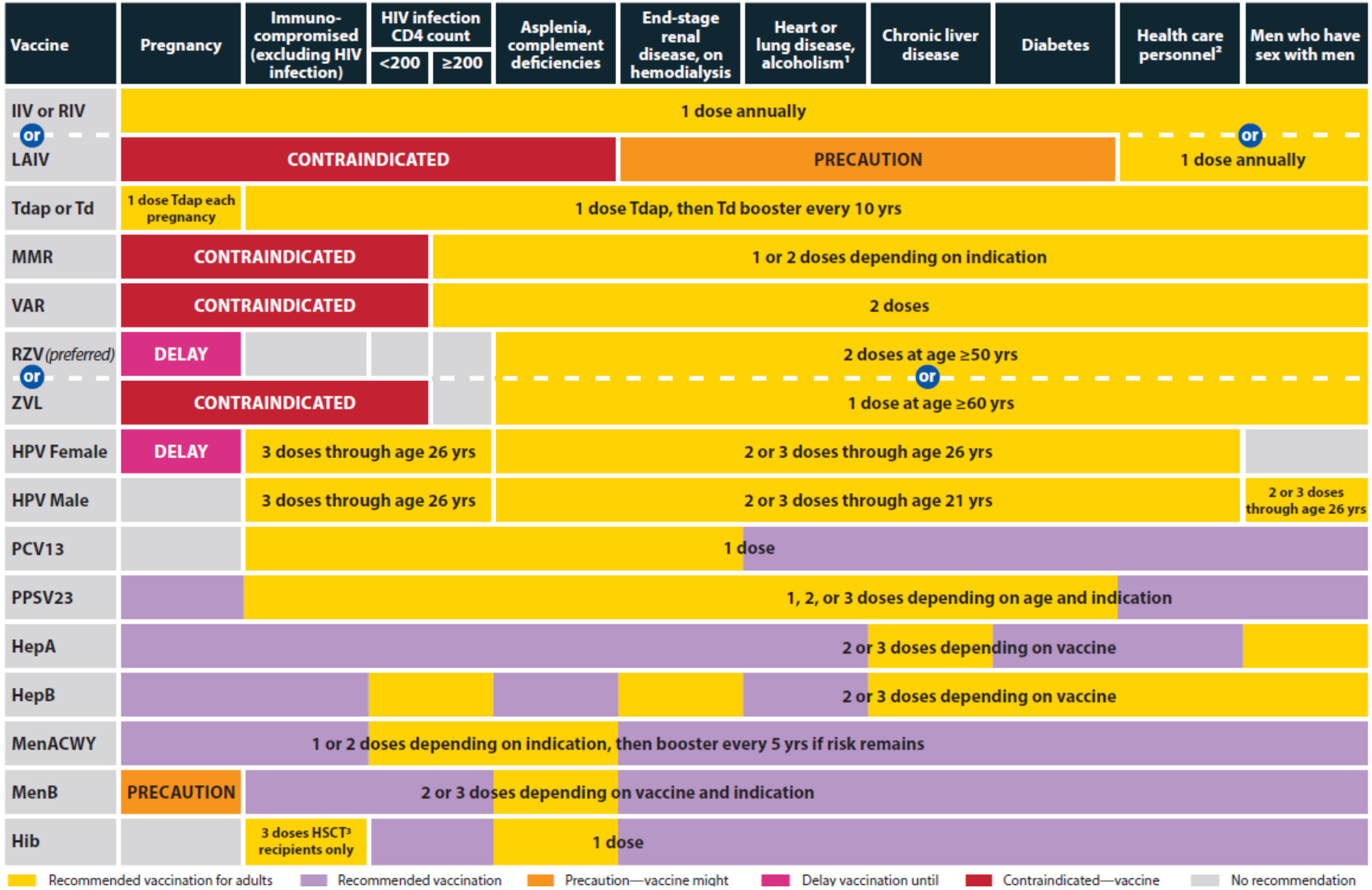
Vaccine	19–21 years	22–26 years	27–49 years	50–64 years	≥65 years
Influenza inactivated (IIV) or **Influenza recombinant** (RIV)	1 dose annually				
or					
Influenza live attenuated (LAIV)	1 dose annually				
Tetanus, diphtheria, pertussis (Tdap or Td)	1 dose Tdap, then Td booster every 10 yrs				
Measles, mumps, rubella (MMR)	1 or 2 doses depending on indication (if born in 1957 or later)				
Varicella (VAR)	2 doses (if born in 1980 or later)				
Zoster recombinant (RZV) *(preferred)*				2 doses	
or				or	
Zoster live (ZVL)				1 dose	
Human papillomavirus (HPV) **Female**	2 or 3 doses depending on age at initial vaccination				
Human papillomavirus (HPV) **Male**	2 or 3 doses depending on age at initial vaccination				
Pneumococcal conjugate (PCV13)	1 dose				
Pneumococcal polysaccharide (PPSV23)	1 or 2 doses depending on indication				1 dose
Hepatitis A (HepA)	2 or 3 doses depending on vaccine				
Hepatitis B (HepB)	2 or 3 doses depending on vaccine				
Meningococcal A, C, W, Y (MenACWY)	1 or 2 doses depending on indication, then booster every 5 yrs if risk remains				
Meningococcal B (MenB)	2 or 3 doses depending on vaccine and indication				
***Haemophilus influenzae* type b** (Hib)	1 or 3 doses depending on indication				

Recommended vaccination for adults who meet age requirement, lack documentation of vaccination, or lack evidence of past infection

Recommended vaccination for adults with an additional risk factor or another indication

No recommendation

Table 2 Recommended Adult Immunization Schedule by Medical Condition and Other Indications United States, 2019



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Resources

Pink Book Webinar Series Resources

- Comprehensive list of resources for ALL the webinars
- Located on the webpage for this webinar with the:
  - Webinar slides
  - Archived recast
  - Webinar questions and answers
  - Transcript

COURSE RESOURCES

Epidemiology and Prevention of Vaccine-Preventable Diseases

- Epidemiology and Prevention of Vaccine-Preventable Diseases (Pink Book) Supplement: www.cdc.gov/vaccines/pubs/pinkbook/supplement.html

Overall Resources

- Current childhood and adult immunization schedules: www.cdc.gov/vaccines/schedules/index.html
- CDC Vaccine Schedules App for Health Care Providers: www.cdc.gov/vaccines/schedules/hcp/schedule-app.html
- Advisory Committee on Immunization Practices (ACIP) recommendations: www.cdc.gov/vaccines/hcp/acip-recs/index.html
- CDC General Best Practice Guidelines for Immunization: www.cdc.gov/vaccines/hcp/acip-recs/general-recs/index.html
- CDC Continuing Education Information: www.cdc.gov/vaccines/ed/ce-credit-how-to.html
- Health Care Personnel Vaccination Recommendations: www.immunize.org/catg.d/p2017.pdf
- Pink Book Webinar Series: www.cdc.gov/vaccines/ed/webinar-epv/index.html
- Vaccines Licensed for Use in the United States Package Inserts: www.fda.gov/BiologicsBloodVaccines/Vaccines/ApprovedProducts/ucm093833.htm
- You Call the Shots: www.cdc.gov/vaccines/ed/youcalltheshots.html

Course Intro and Objectives

- What is the Advisory Committee on Immunization Practices (ACIP)?: www.cdc.gov/vaccines/hcp/conversations/downloads/vacsafe-acip-color-office.pdf
- CDC Immunization Resources for You and Your Patients: www.cdc.gov/vaccines/hcp/admin/downloads/Resource-Booklet.pdf
- Parents' Guide to Childhood Immunizations: www.cdc.gov/vaccines/parents/tools/parents-guide/index.html
- Order Information for Free CDC Immunization Materials for Providers and Patients: wwwn.cdc.gov/pubs/CDCInfoOnDemand.aspx

Principles of Vaccination

- Immune System Research: www.niaid.nih.gov/research/immune-system-research
- What is the Immune System?: www.vaccines.gov/basics/work/prevention
- Understanding How Vaccines Work: www.cdc.gov/vaccines/hcp/conversations/downloads/vacsafe-understand-color-office.pdf
- Vaccines Work: www.vaccines.gov/basics/work/index.html
- Vaccine Basics: How Vaccines Work: www.vaccineinformation.org/how-vaccines-work/
- The History of Vaccines: How Vaccines Work: www.historyofvaccines.org/content/how-vaccines-work

General Best Practice Guidelines

- Ask the Experts-Scheduling Vaccines FAQs: www.immunize.org/askexperts/scheduling-vaccines.asp
- Ask the Experts-Combination Vaccines FAQs: www.immunize.org/askexperts/experts_combo.asp
- Ask the Experts-Precautions and Contraindications FAQs: www.immunize.org/askexperts/precautions-contraindications.asp
- Foreign Language Vaccine-Preventable Disease Terms: www.cdc.gov/vaccines/pubs/pinkbook/downloads/appendices/B/foreign-products-tables.pdf
- Guide to Contraindications and Precautions to Commonly Used Vaccines: www.immunize.org/catg.d/p3072a.pdf
- Guidelines for Vaccinating Pregnant Women: www.cdc.gov/vaccines/pregnancy/hcp/guidelines.html
- IDSA 2013 Clinical Practice Guideline for Vaccination of the Immunocompromised Host: www.idsociety.org/Guidelines/Patient_Care/IDSA_Practice_Guidelines/Vaccination_of_the_Immunocompromised_Host/
- Interval Between Antibody-Containing Products and Measles- and Varicella-Containing Vaccines: www.cdc.gov/vaccines/pubs/pinkbook/downloads/appendices/a/mmr_ig.pdf

January 2019