Vaccine and Disease Prevention

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Who am I ?

- Dr. Wei Lu
- DVM or BVSc - Veterinarian China 1982
- MS University of Nebraska-Lincoln 1989
- PhD – University of Nebraska Omaha Medical Center 1995

- Animal disease research (1982 -)
- Veterinary vaccine Research and Development (1994 -)

** 1st US Swine flu vaccine (H1 & H3) 2001

(Infectious) Disease Intervention

- Post Intervention - Treatment
  - Antibiotics – Pharmaceutical approach
  - Antiserum therapy - Biological approach
    - Rabies
    - Tetanus
- Prior Intervention - Prevention
  - Vaccination – Biological approach

Vaccine

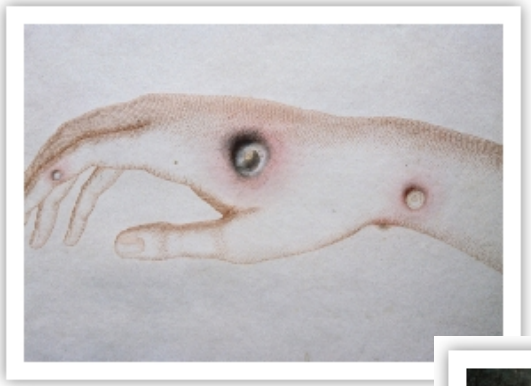
- Vaccine is a preparation containing weakened (still live) or dead microbes (part or whole) of the kind that cause a disease, administered to stimulate the immune system to produce protection against that disease

Vaccine

- The term *vaccine* derives from Edward Jenner's 1796 use of *cow pox* (Latin *variola vaccinia*, adapted from the Latin *vaccīn-us*, from *vacca*, cow), to inoculate humans, providing them protection against smallpox

1st Vaccination - Edward Jenner and Smallpox

- Edward Jenner
- Sarah Nelmes – dairymaid
- James Philips (8 year old boy)
- 14 May 1796



How does the vaccine work ?

- A **vaccine** is used to stimulate the body to induce specific immunity against the specific antigens (organisms)

- **Immunity** is a biological term that describes a state of having sufficient biological defenses to avoid infection, disease, or other unwanted biological invasion

The Types of Immunity

- Nonspecific immunity
  - Includes things such as physical barriers, mucus production, inflammation, fever, and phagocytosis
  - Directed against all pathogens; is the initial defense against invading agents
- Specific immunity
  - Takes over when the nonspecific mechanisms fail
  - Targeted for a specific antigen; has memory
  - Arises from B- and T-lymphocytes

The Types of Immunity

- Cell-mediated immunity
  - T-lymphocytes directly attack the invading antigen
  - Important for protecting against intracellular bacterial or viral infections, fungal diseases, and protozoal diseases

- Antibody-mediated immunity
  - B-lymphocytes produce antibodies that react to antigen
  - Important for extracellular phases of systemic viral and bacterial infections and protection against endotoxin and exotoxin-induced disease

Ways to Acquire Specific Immunity

- Active immunity
  - Arises when an animal receives an antigen that activates B- and T-lymphocytes
  - Creates memory
- Passive immunity
  - Arises when an animal receives antibodies from another animal
  - Provides immediate onset of immunity, but the animal is protected for a shorter time (no memory)

- Natural immunity
  - Acquired during normal biological experiences
- Artificial immunity
  - Acquired through medical procedures

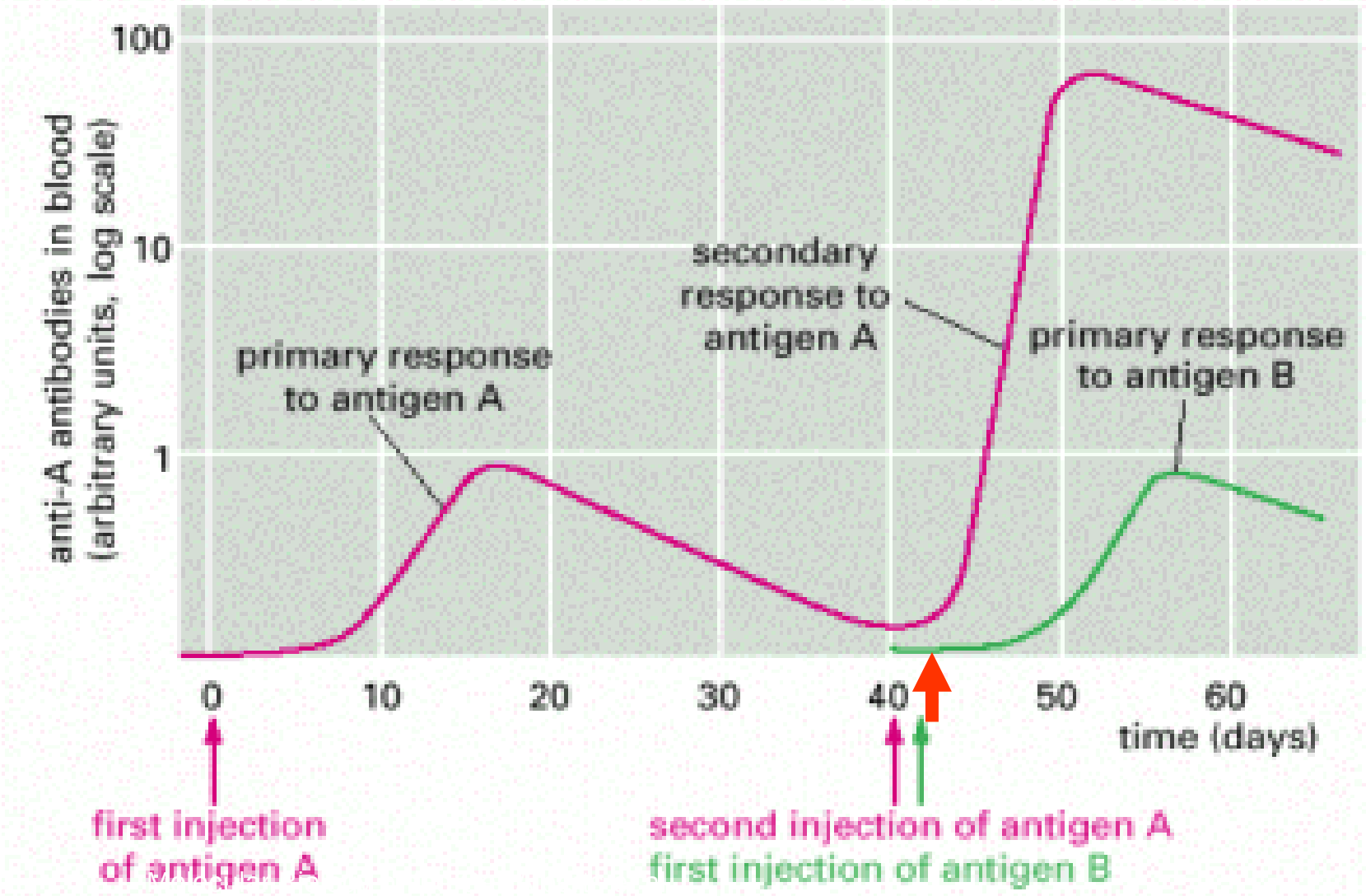
Vaccination

- Vaccination is the administration of antigenic material (a vaccine) to stimulate the immune system of an individual to develop adaptive immunity to a disease

- Injection - intramuscular, subcutaneous and intradermal
- Oral
- Intranasal

Patient exposed to pathogen
Carrying antigens A and B

It works like this



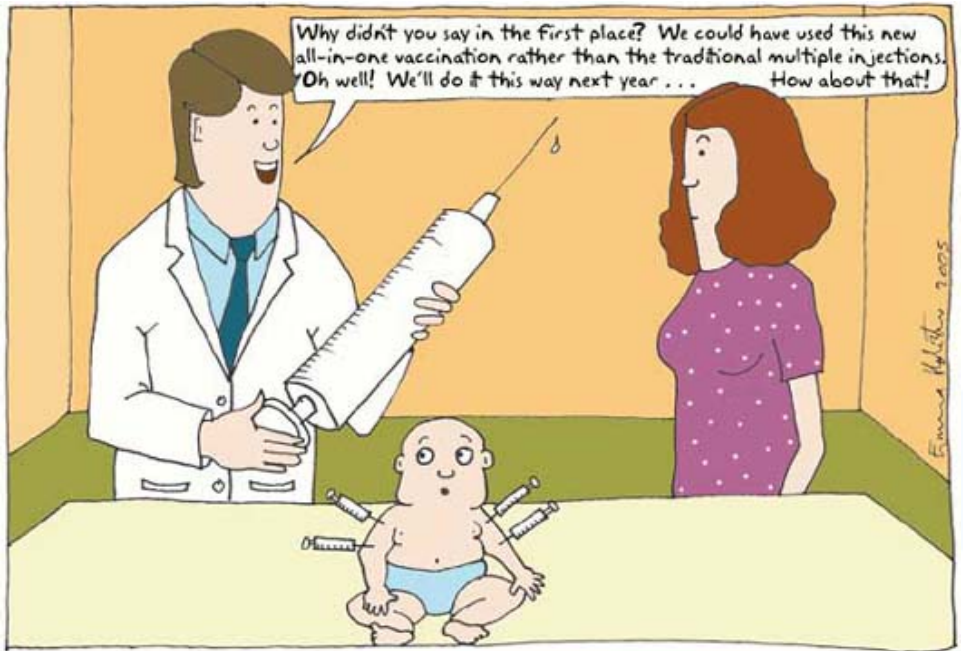
Vaccines can be divided into two types

- Live attenuated
- Inactivated (Killed)

Inactivated Vaccines fall into different categories

- Viruses
- Bacteria

- Individual proteins from pathogen (Subunit)
- Pathogen specific complex sugars (PLS)

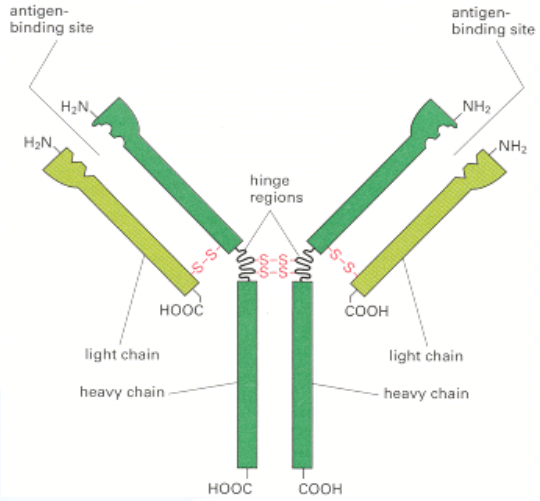


Inactivated Vaccines

- No chance of recreating live pathogen
- Less interference from circulating antibody than live vaccines

Inactivated Vaccines

- Cannot replicate I the body and generally not as effective as live vaccines
- Usually require revaccination doses (boost)
- Immune response is mostly antibody based
- Safe
- Usually contain adjuvant
- Liquid form
- Contain preservatives (Thimerosal..)



Some Inactivated Vaccines

- Viral

  Polio, hepatitis A, rabies, influenza

- Bacterial

  Pertussis, typhoid, cholera, plague

*not used in the United States

Some Inactivated Vaccines contain purified proteins rather than whole bacteria/viruses

- Proteins

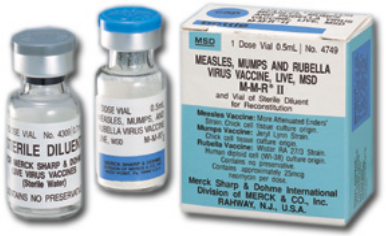
  hepatitis B, influenza, acellular pertussis, human papillomavirus, anthrax, Lyme

- Toxins

  diphtheria, tetanus

Live Attenuated Vaccines

- Attenuated (weakened) form of the "wild" virus or bacterium
- Can replicate themselves so the immune response is more similar to natural infection
- Usually effective with one dose



Live Attenuated Vaccines

- Stimulate both cellular immunity and humoral immunity (antibody)
- Longer duration of immunity (protection) – months and years
- Freeze-dried with stabilizer

Live Attenuated Vaccines - disadvantages

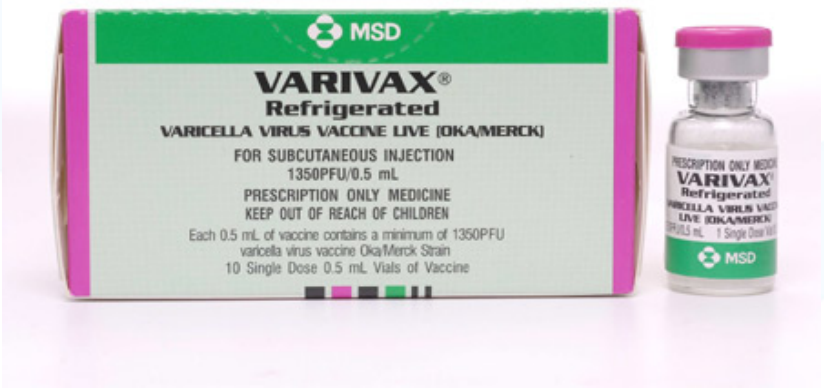
- Severe reactions possible especially in immune compromised patients
- Worry about recreating a wild-type pathogen that can cause disease ?
- Fragile – must be stored carefully

TABLE 9. Vaccine storage temperature recommendations

Vaccines	Vaccine storage temperature
Diphtheria-tetanus, or pertussis-containing vaccines	35°F–46°F (2°C–8°C) Do not freeze
Haemophilus influenzae type b conjugate vaccines (Hib)	35°F–46°F (2°C–8°C) Do not freeze
Hepatitis A and hepatitis B vaccines	35°F–46°F (2°C–8°C) Do not freeze
Inactivated polio vaccine	35°F–46°F (2°C–8°C) Do not freeze
Meningococcal conjugate vaccine	35°F–46°F (2°C–8°C) Do not freeze
Meningococcal polysaccharide vaccine	35°F–46°F (2°C–8°C) Do not freeze
Pneumococcal conjugate vaccine	35°F–46°F (2°C–8°C) Do not freeze
Pneumococcal polysaccharide vaccine	35°F–46°F (2°C–8°C) Do not freeze
Measles, mumps, and rubella vaccine in the lyophilized (freeze-dried) state[§]	35°F–46°F (2°C–8°C) Lyophilized (freeze-dried) vaccine can be stored at freezer temperature
Measles, mumps, rubella, and varicella vaccine	≤5°F (≤-15°C)
Trivalent inactivated influenza vaccine	35°F–46°F (2°C–8°C) Do not freeze
Live-attenuated influenza vaccine	≤5°F (≤-15°C)
Varicella vaccine	≤5°F (≤-15°C)
Herpes zoster vaccine	≤5°F (≤-15°C)

Some Live Attenuated Vaccines

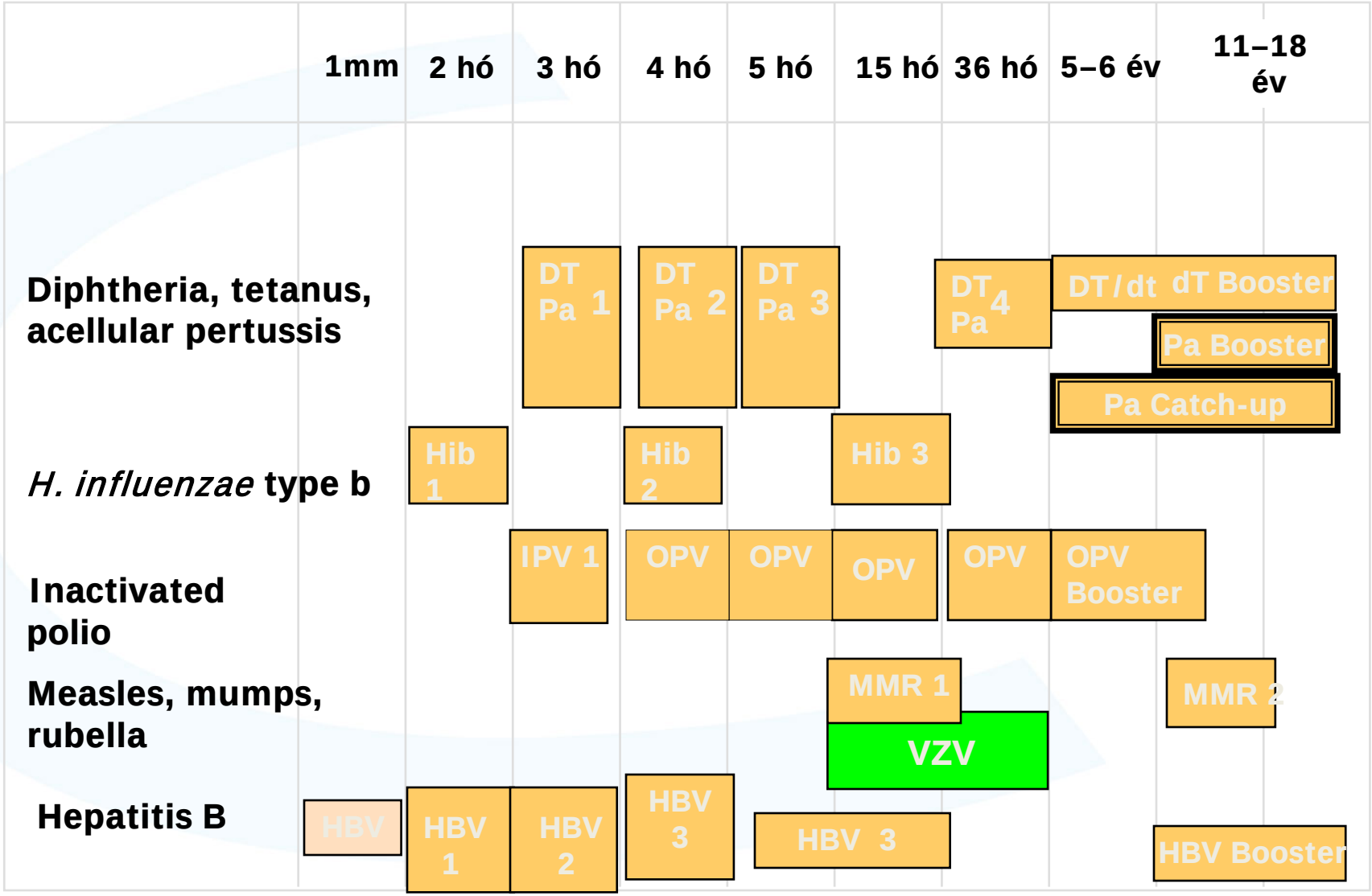
- Viral
  - measles, mumps,
  - rubella, vaccinia,
  - varicella/zoster,
  - yellow fever, rotavirus,
  - intranasal influenza,
  - oral polio
- Bacterial
  - BCG (TB), oral typhoid



Routinely Recommended Vaccines for Disease Prevention

- Diphtheria
- *Haemophilus influenzae type b (Hib)*
- Hepatitis A
- Hepatitis B
- Herpes zoster (shingles)
- Human papillomavirus (HPV)
- Influenza
- Measles
- Meningococcal disease
- Mumps
- Pertussis
- Pneumococcal disease
- Polio
- Rotavirus
- Rubella
- Tetanus
- Varicella (chickenpox)

Pediaric Vaccination Scedule in Europe

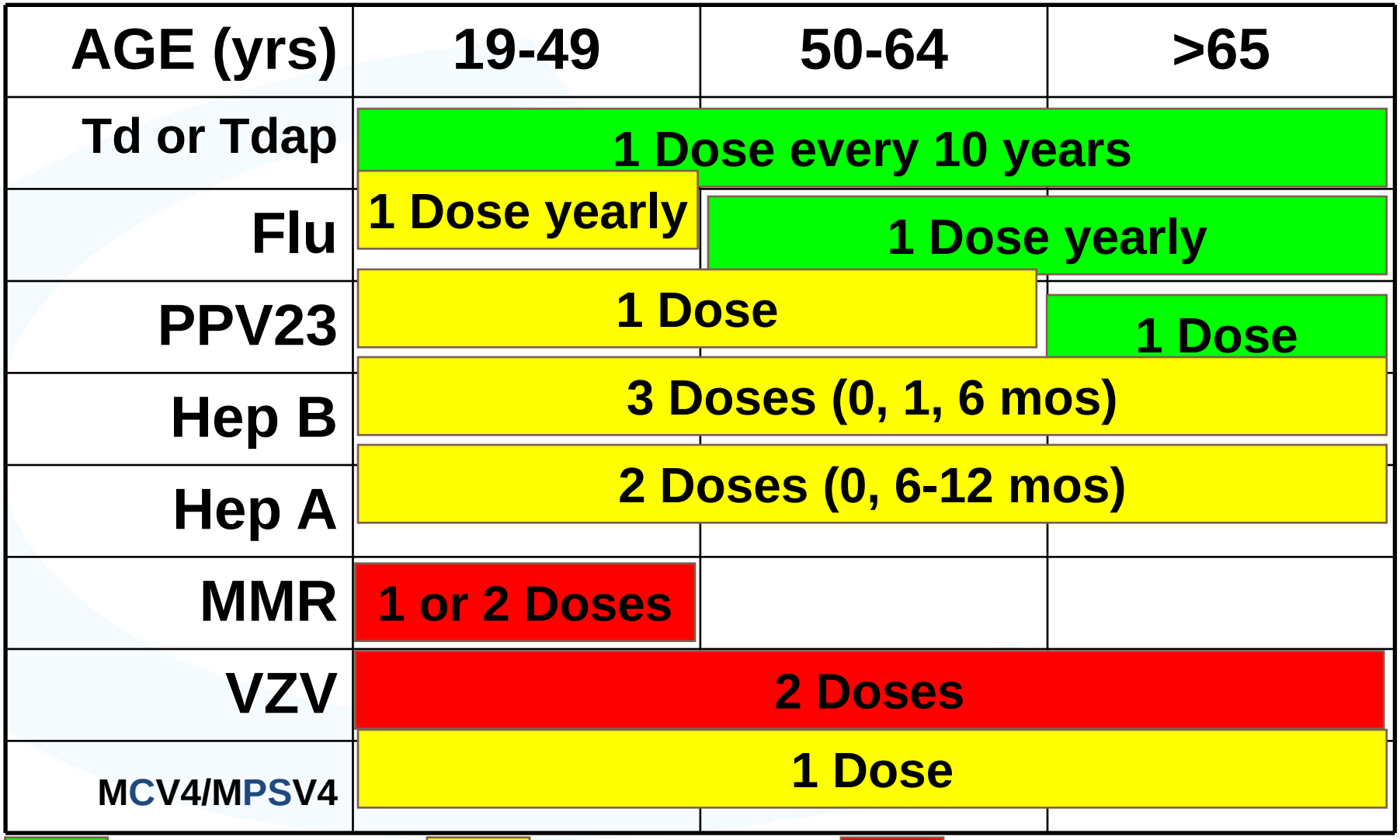


New Vaccine Recommendation

- Rota vírus vaccine: 2, 4, 6 m
- HPV: 12 -26) y

Recommended Adult Immunization Schedule

OCT 2005–SEPT 2006 (ACIP)

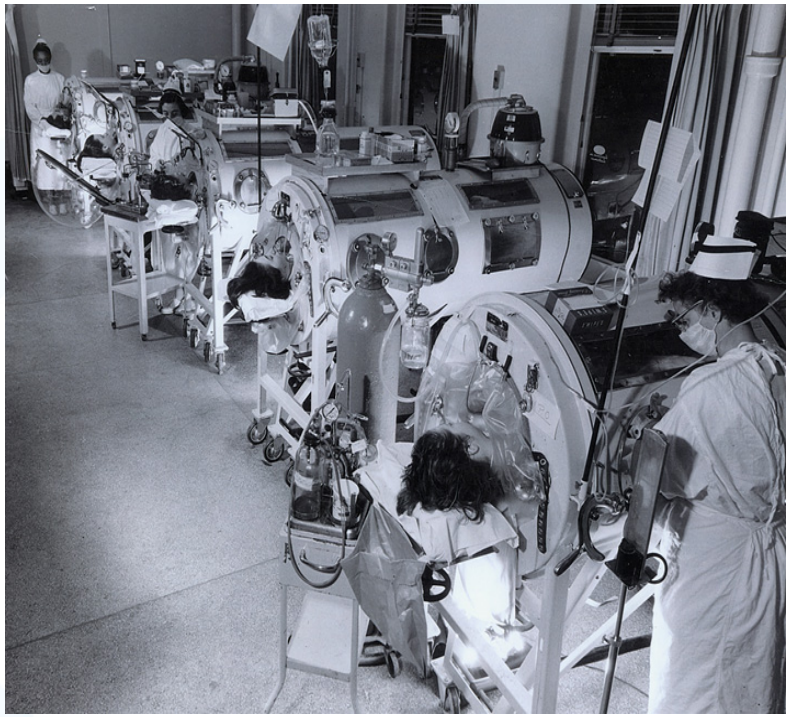


Everyone | If at risk | No disease/No record

Polio

Polio

- Affects mostly children under 3 (50% of all cases)
- Asymptomatic, 10% with ‘minor illness’: fever, nausea, vomiting
- 0.5 -1% infections leads to irreversible paralysis (AFP), with maximum effect taking place in 3-4 days
- Legs affected more than arms; paralysis of respiratory muscles is life-threatening
- Humans are the only reservoir for the poliovirus. The virus does not naturally reproduce in any other species.



Polio

Polio

Evidence of sporadic epidemics of polio predate recorded history

- **1789**, British physician Michael Underwood - first clinical description of the disease.
- **1840**, Jacob Heine - clinical features of the disease and its involvement of the spinal cord.
- **1894**, first outbreak of polio in epidemic form in the U.S. occurs

Polio

- **1908**, Karl Landsteiner & Erwin Popper identify the polio virus by transmitting the disease to a monkey.
- **1916**, large epidemic of polio in the US
- **1921**, FDR contracts polio (at 39).
- **1929**, Philip Drinker & Louis Shaw develop the “iron lung” to aid respiration.

Polio

- **1930s**, 2 strains of the poliovirus are discovered (later it was determined that there were 3).
- **1933**, FDR inaugurated president.
- **1935**, Maurice Brodie &John Kolmer test polio vaccines, with disastrous results.
- **1947 - 50**, Dr. Jonas Salk is recruited by the University of Pittsburgh to develop a virus research program.
- **1953**, Salk and associates develop a potentially safe, inactivated (killed), injected polio vaccine.

Polio

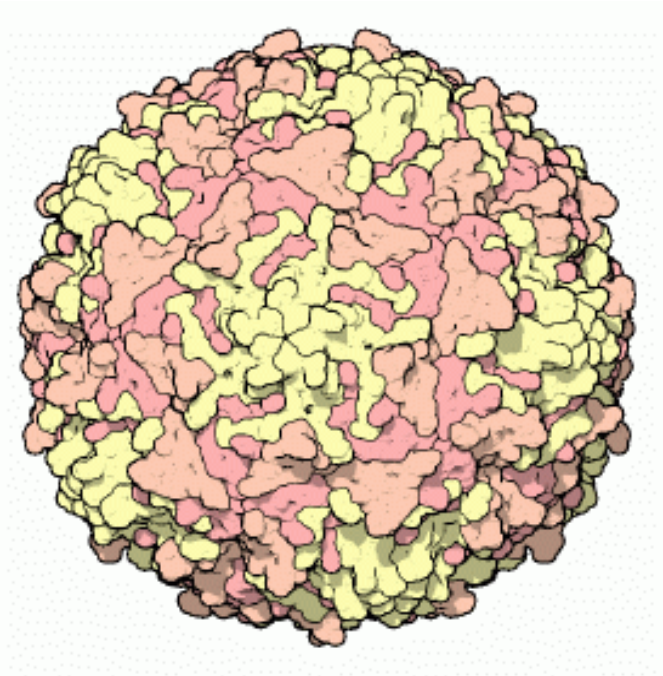
- **1954**, ~2 m children participate in the field trials.
- **1955**, news of the success of the trials is announced by Dr. Thomas Francis on April 12, the tenth anniversary of FDR's death.
- **1955 - 57**, incidence of polio in the U.S. falls by 85 - 90%.
- **1957 - 59**, mass clinical trials of Albert Sabin's live, attenuated vaccine in Russia.
- **1962**, the Salk vaccine replaced by the Sabin vaccine for most purposes because it is easier to administer and less expensive.

Polio

- **1979**, last case of polio caused by “wild” virus in U.S.; last case of smallpox in the world.
- **1980**, the first National Immunization Day for polio held in Brazil.
- **1988**, Rotary International, PanAmerican HO, WHO, CDC, UNICEF begin international campaign to stop transmission of polio everywhere in the world.
- **1999**, inactivated polio vaccine replaces oral polio vaccince as recommended method of polio immunization in the United States.

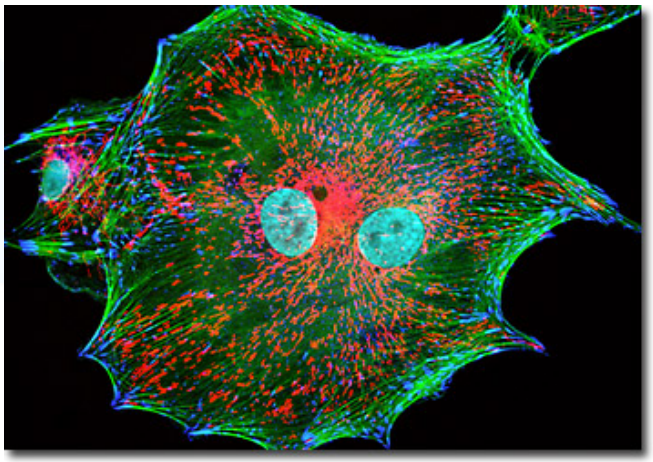
Salk Polio Vaccine

- **Formaldehyde-fixed**
- **No reversion**



Sabin Polio Vaccine

- **Attenuated by passage in foreign host (monkey kidney cells)**
- **Selection to grow in new host**
- **less suited to original host**
- **Grows in epithelial cells**
- **Does not grow in nerves**
- **No paralysis**
- **Local gut immunity (IgA)**

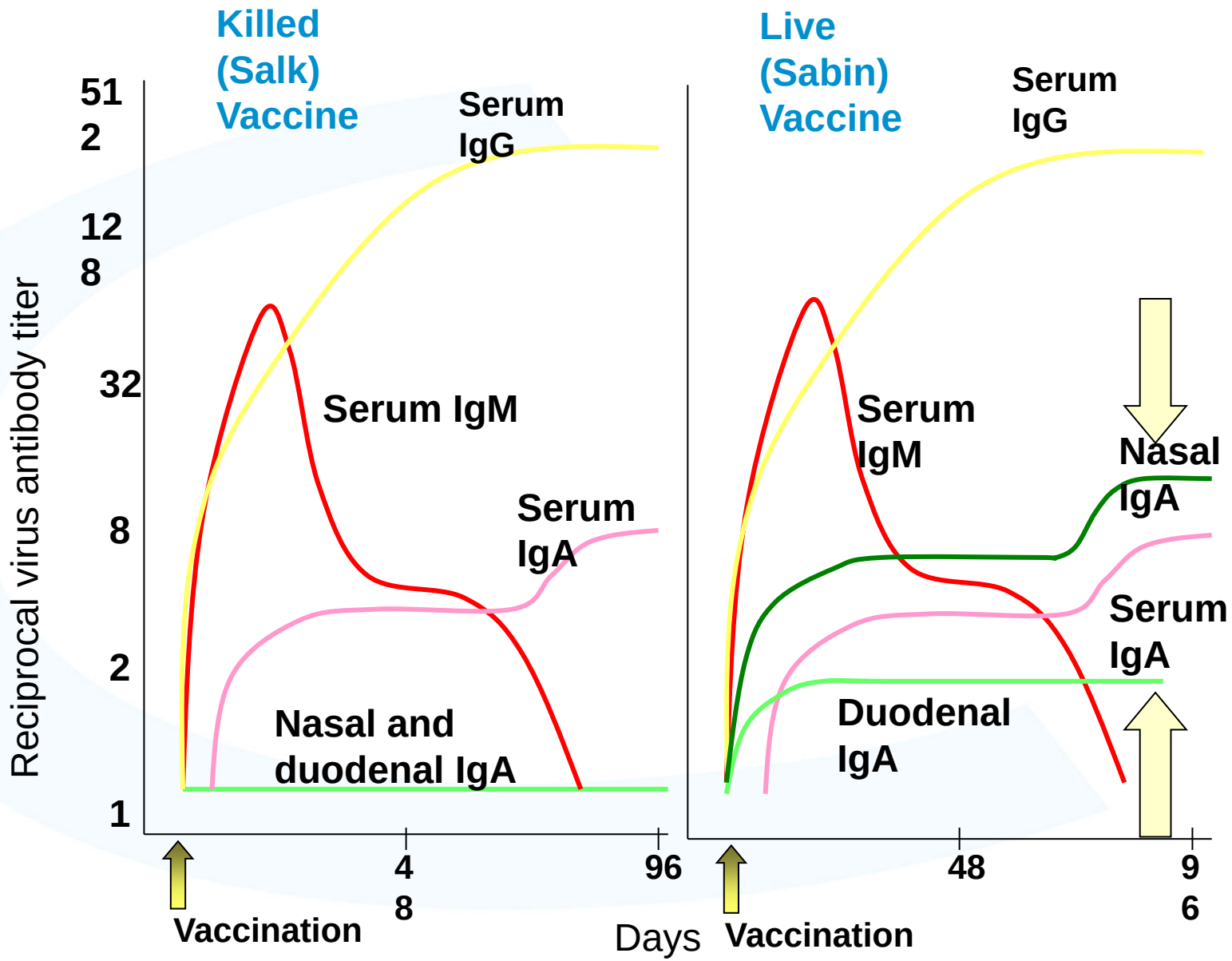


Vaccination: Salk vs Sabin

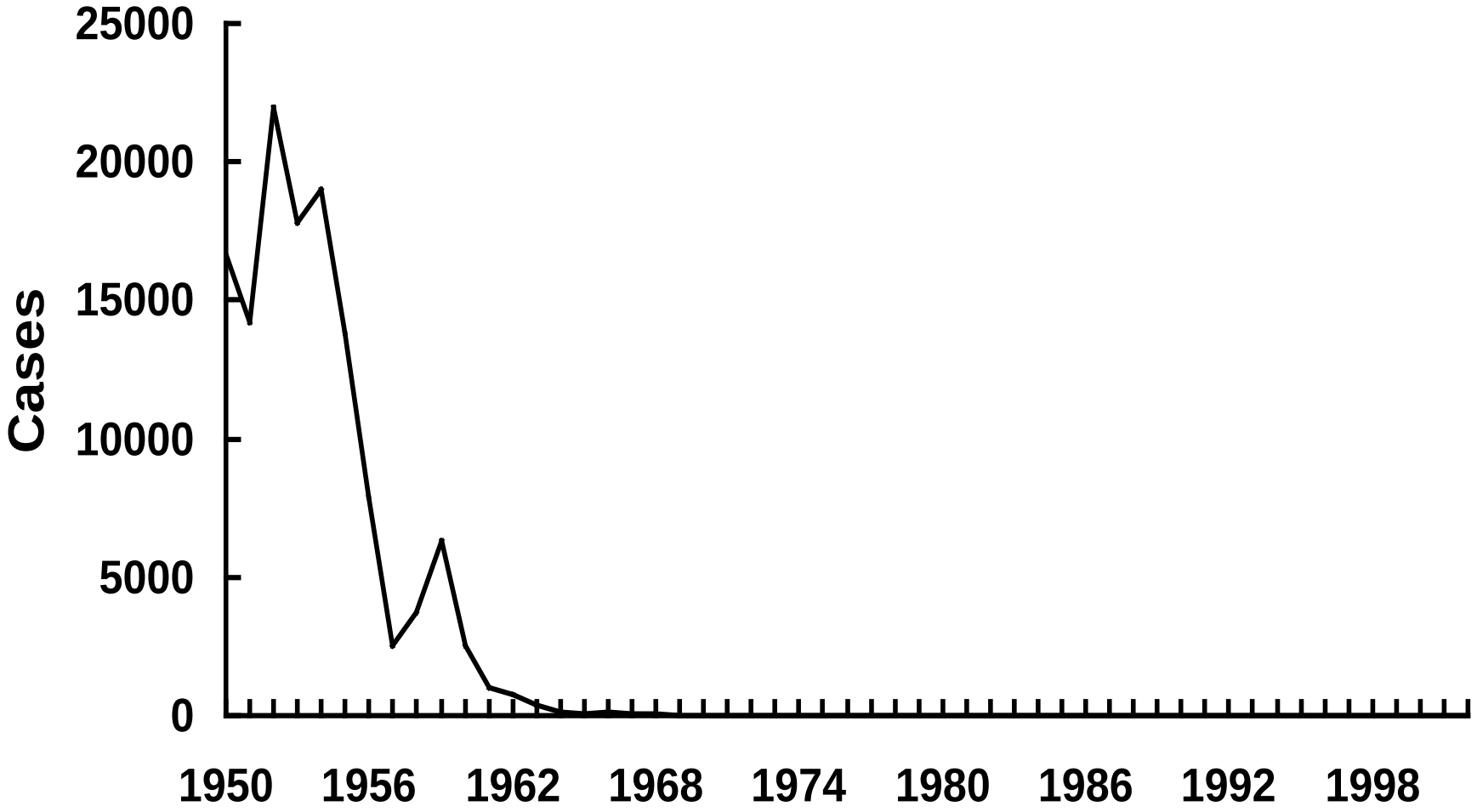
- IPV (Salk): Also induces humoral immunity via antibodies. However, it induces very low levels of immunity to poliovirus locally, inside the gut. As a result, it provides individual protection against polio paralysis but, unlike OPV, cannot prevent the spread of wild polio virus.

- OPV (Sabin): provides immunity to all 3 strains of polio. Induces humoral immunity systemically as well as local GI mucosal immunity (which limits transmission during outbreaks).

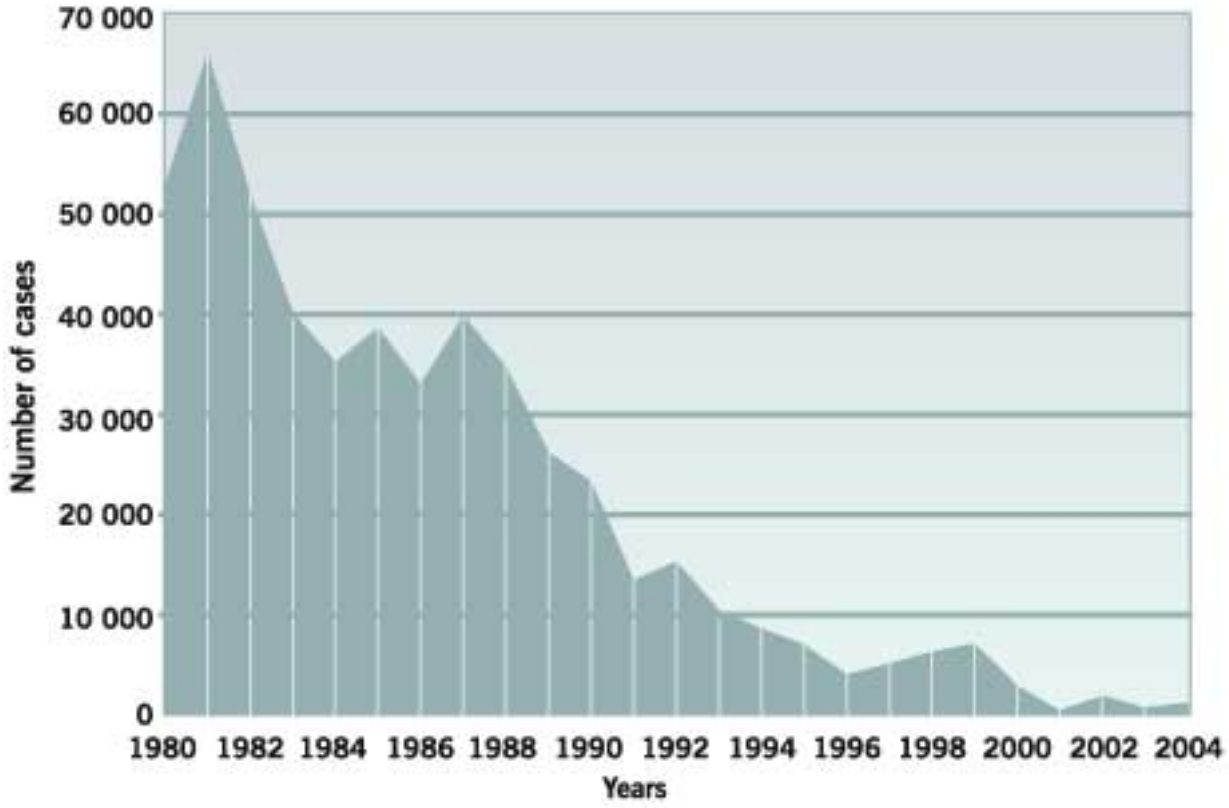
Live virus generates a more complete immune response



Polio Case in the US



Global number of poliomyelitis cases, 1980-2004

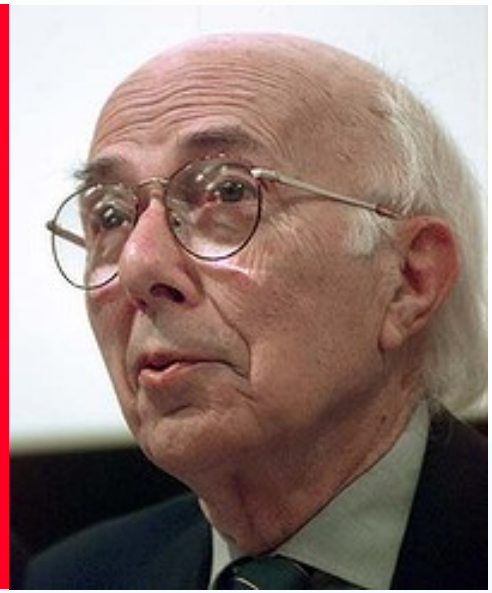


The Fight Against POLIO

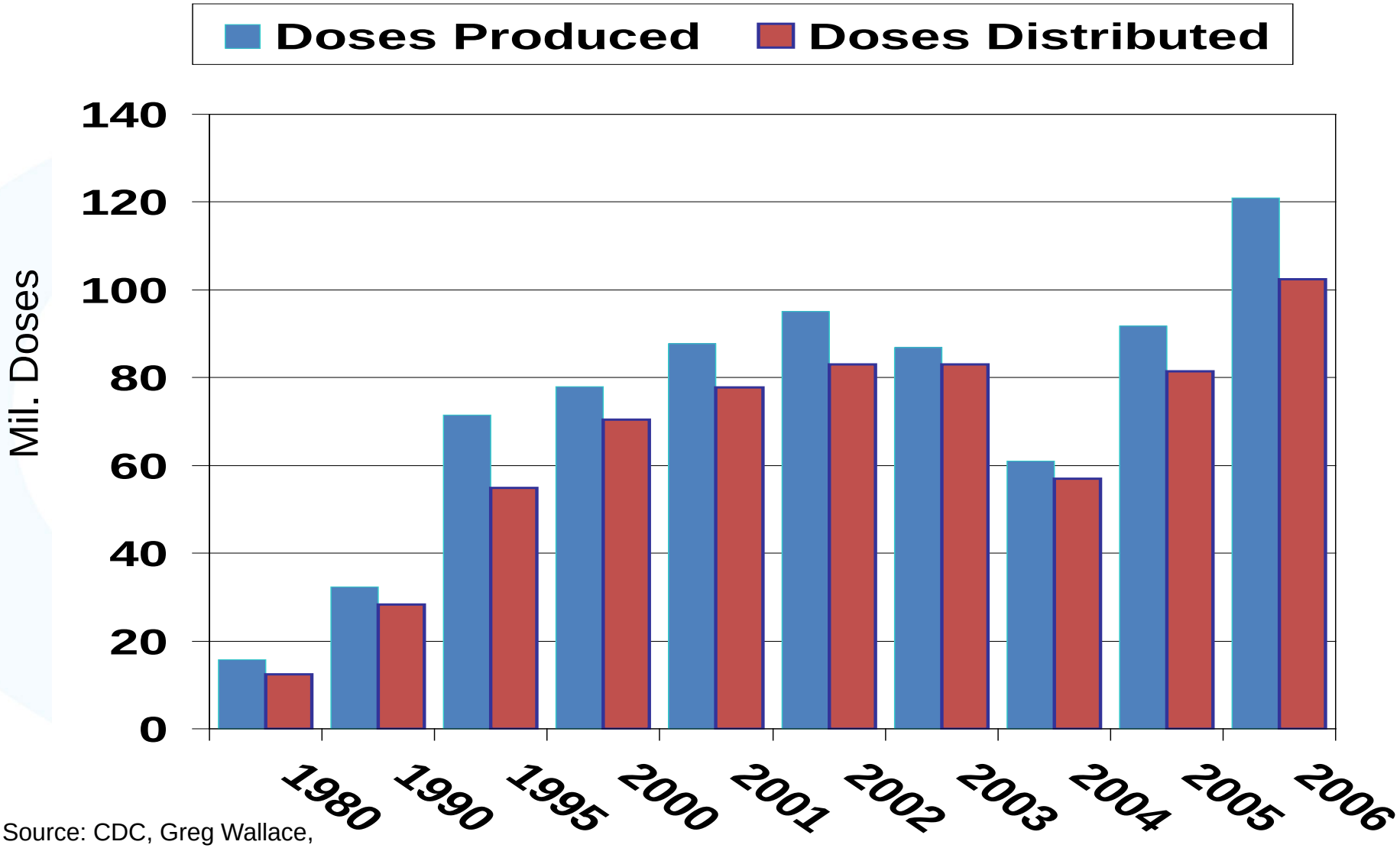
Jonas Salk
1914-1995
Developed "killed" virus vaccine

First Day of Issue
March 8, 2006

Albert Sabin
1906-1993
Developed "live" virus vaccine



A Record 120M Doses Were Supplied for the 2006-2007 Influenza Season



Source: CDC, Greg Wallace,
Vaccine Supply & Assurance Branch

Regulation of Vaccines

- Human vaccines
  - Food and Drug Administration

- Veterinary Vaccines
  - USDA Center for Veterinary Biological

Requirements for Vaccine Manufacturers

- Permit for each manufacturer
- Product license for each vaccine
- Strict guidelines in development, production, quality control testing procedures to ensure:
  - **Safe** – ensure the safety in all ages and conditions
  - **Pure** – ensure the purity of seeds, raw materials and final product
  - **Potent** – potency test for each serial before releasing
  - **Efficacious** – complete demonstration of efficacy (protection) before license

New Vaccine Development

- Veterinary Vaccines (avg. 3-6 + year)
  - Research
  - Development
  - Clinical
- Human Vaccines (avg. 5-10 + years)
  - Phase 1
  - Phase 2
  - Phase 3
  - Phase 4

Concerns on Vaccine and Vaccinations

- Vaccination vs non-vaccination ?
- Does a vaccine work for everyone? 100% safe?
- Religion and politics

HPV Vaccine vs Mental Retardation?

IT IS A FACT

- Vaccines help the prevention of infectious diseases and save lives in humans and animals!

Thank you

for your attention!