

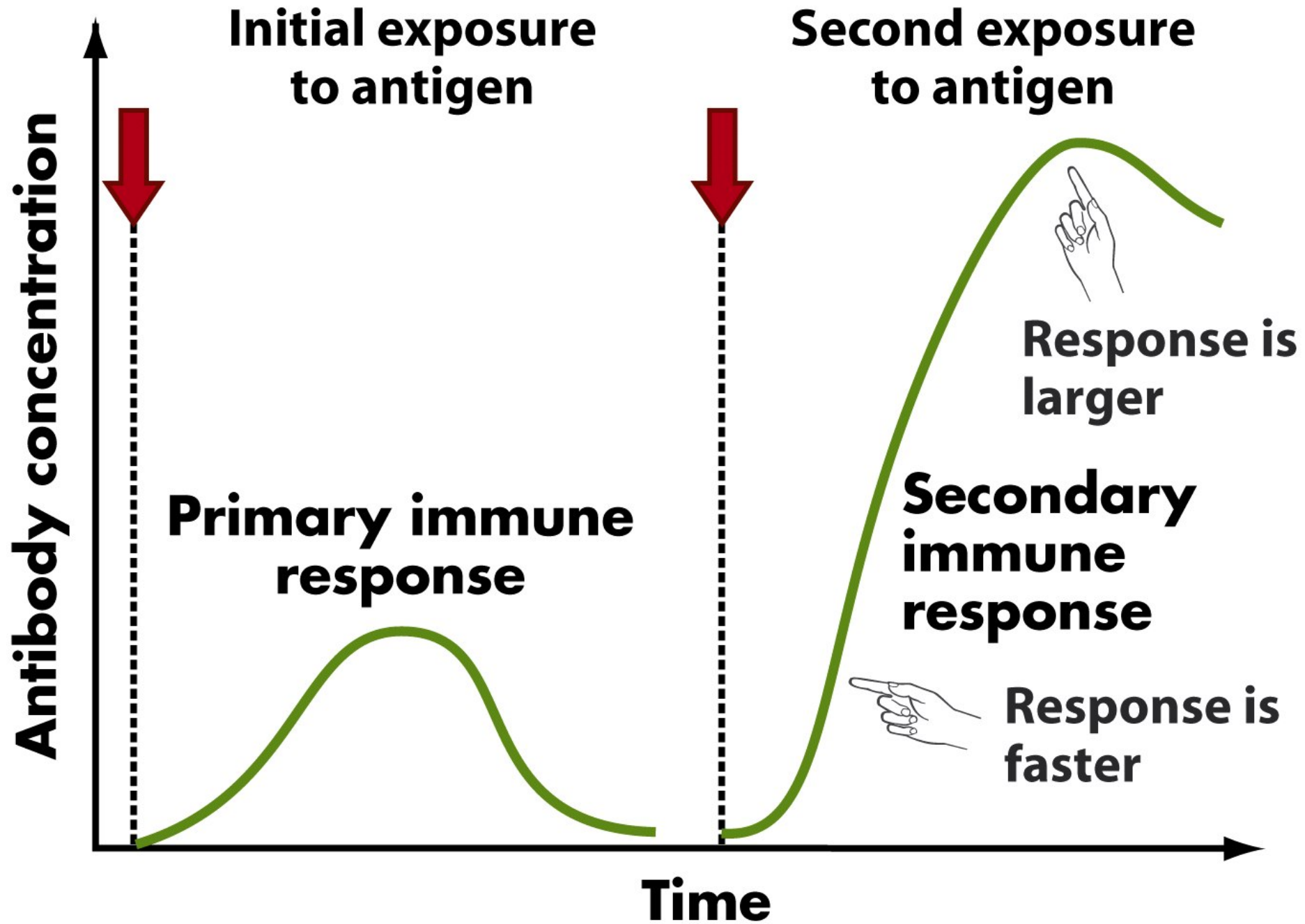
# Immunization (I)

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# Objectives of this lecture

**By the end of this lecture you will be able to:**

- ① Realize the significance of immunization
- ② Describe how vaccines work
- ③ Distinguish between different types of vaccines



# What are vaccines?

- Biological preparations that direct the immune system toward a particular disease in an antigen-specific manner





# Edward Jenner

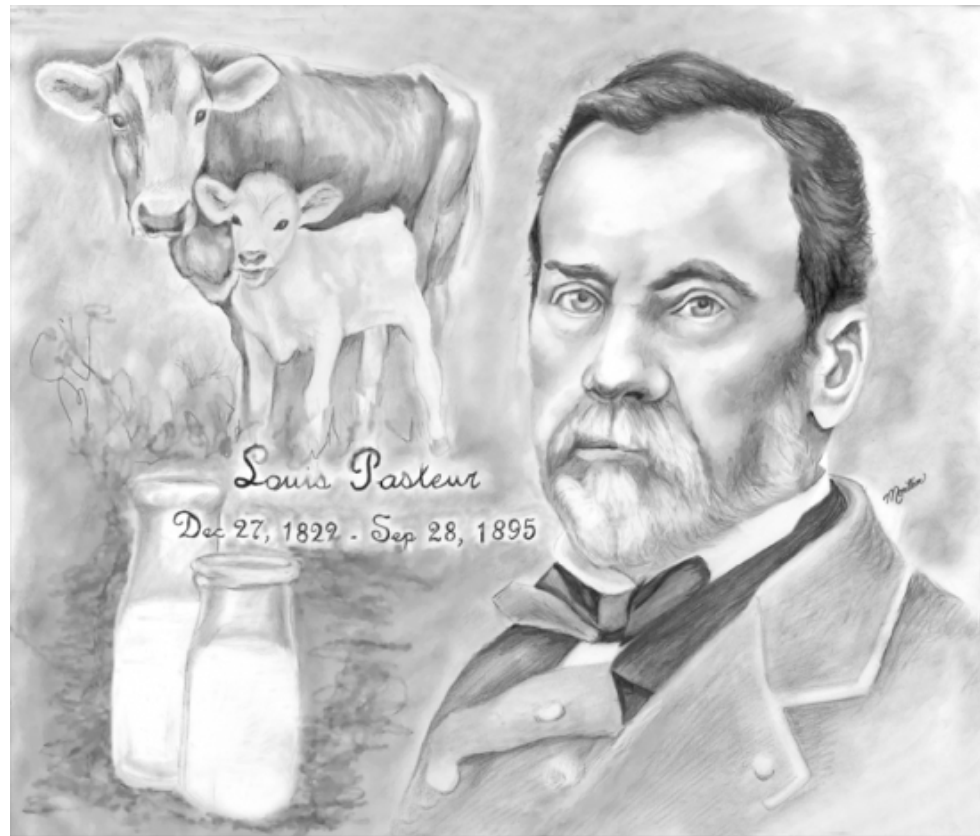
On 14-5-1796 Edward Jenner took pus from the hand of a milkmaid (Sarah Nelmes) with cowpox, inoculated an 8-year-old boy (James Phipps) with it, and six weeks later variolated the boy's arm with smallpox, afterwards observing that the boy did **NOT** catch smallpox.



# Louis Pasteur

- Pasteur produced the first vaccine for rabies by growing the virus in rabbits, and then weakening it by drying the affected nerve tissue.
- The vaccine had been tested only on eleven dogs before its first human trial.
- This vaccine was first used on 9-year old (Joseph Meister), on July 6, 1885





- The term “vaccine” was coined by Luis Pasteur
- It is derived from the Latin word “vaccinus”, which means “related to cows”

# Significance of vaccines

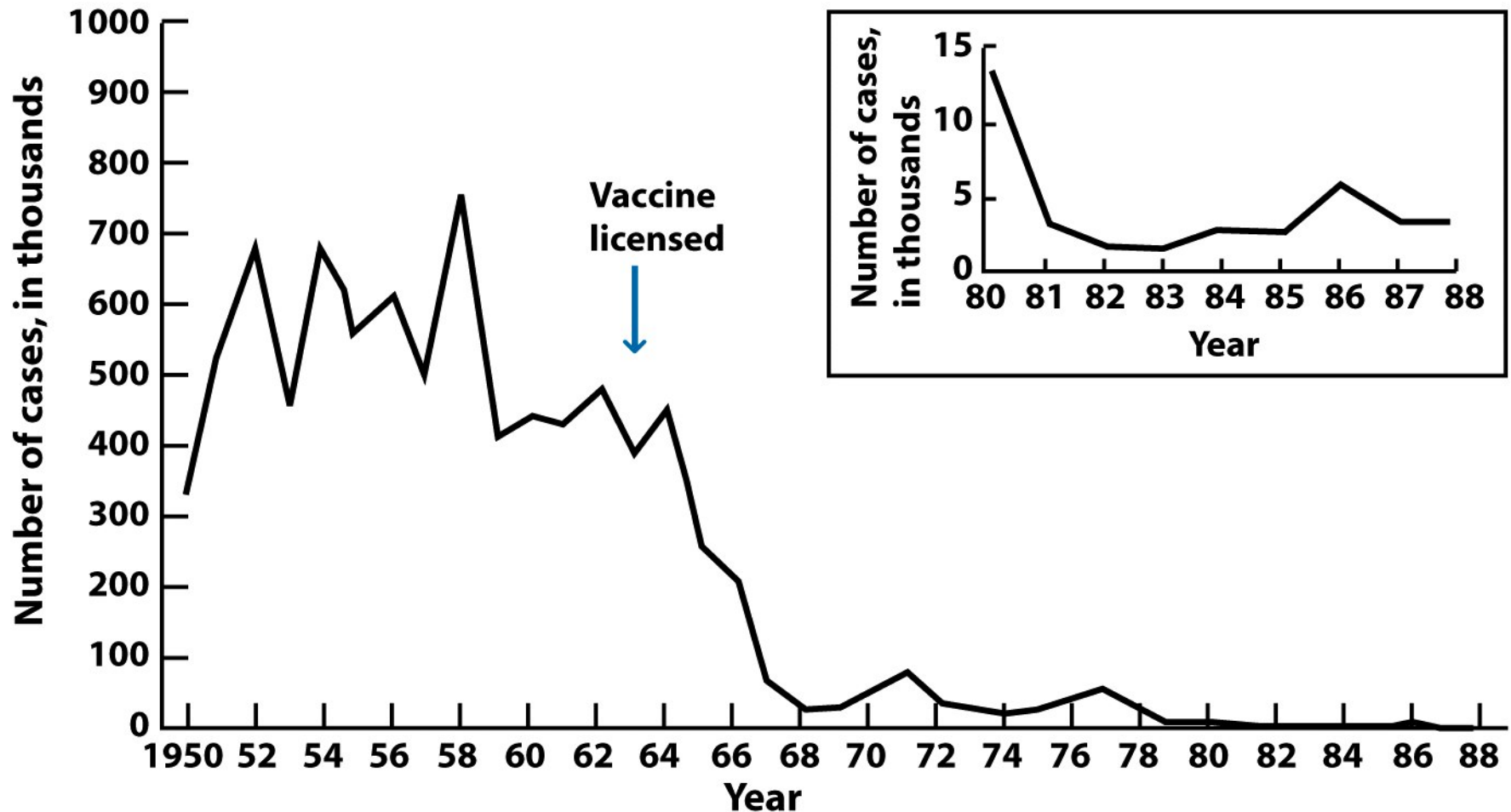















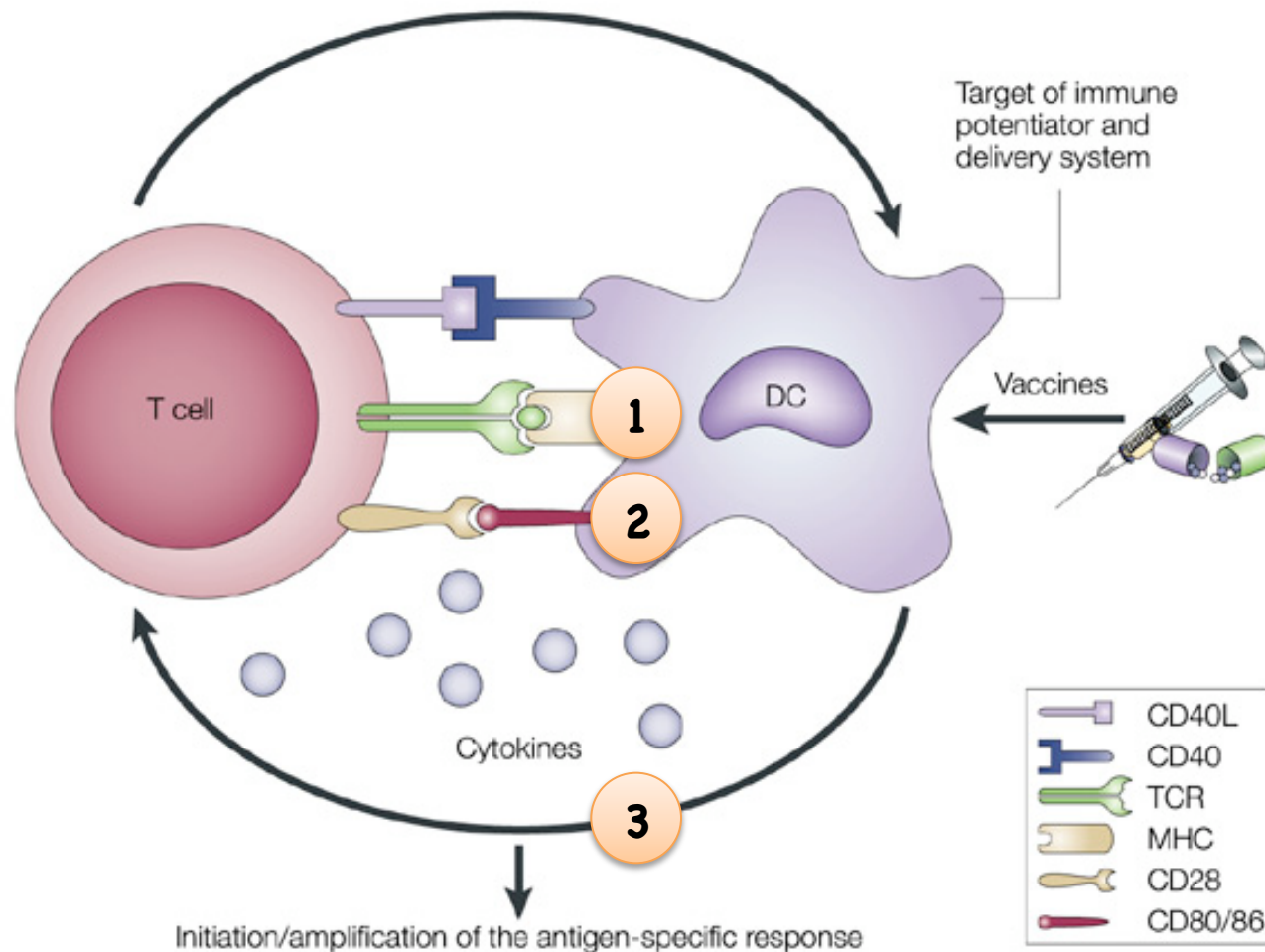


Figure 19-2  
Kuby IMMUNOLOGY, Sixth Edition  
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Age	DTaP	HBV	HiB	IPV	MMR	Var	PCV	Men-C	Tdap	HPV	OPV	HAV	BCG	Meas
@birth														
2 m														
4 m														
6 m														
9 m														
12 m														
18 m														
24 m														
4-6 y														
12 y														
14-16 y														

# T cell activation by DC





**CMI**

**Cytotoxic T cell**

**T<sub>C</sub> cell**

**Dendritic cell**

IFN- $\gamma$   
TNF- $\beta$

IL-4  
IL-5  
IL-13

**Antibody**

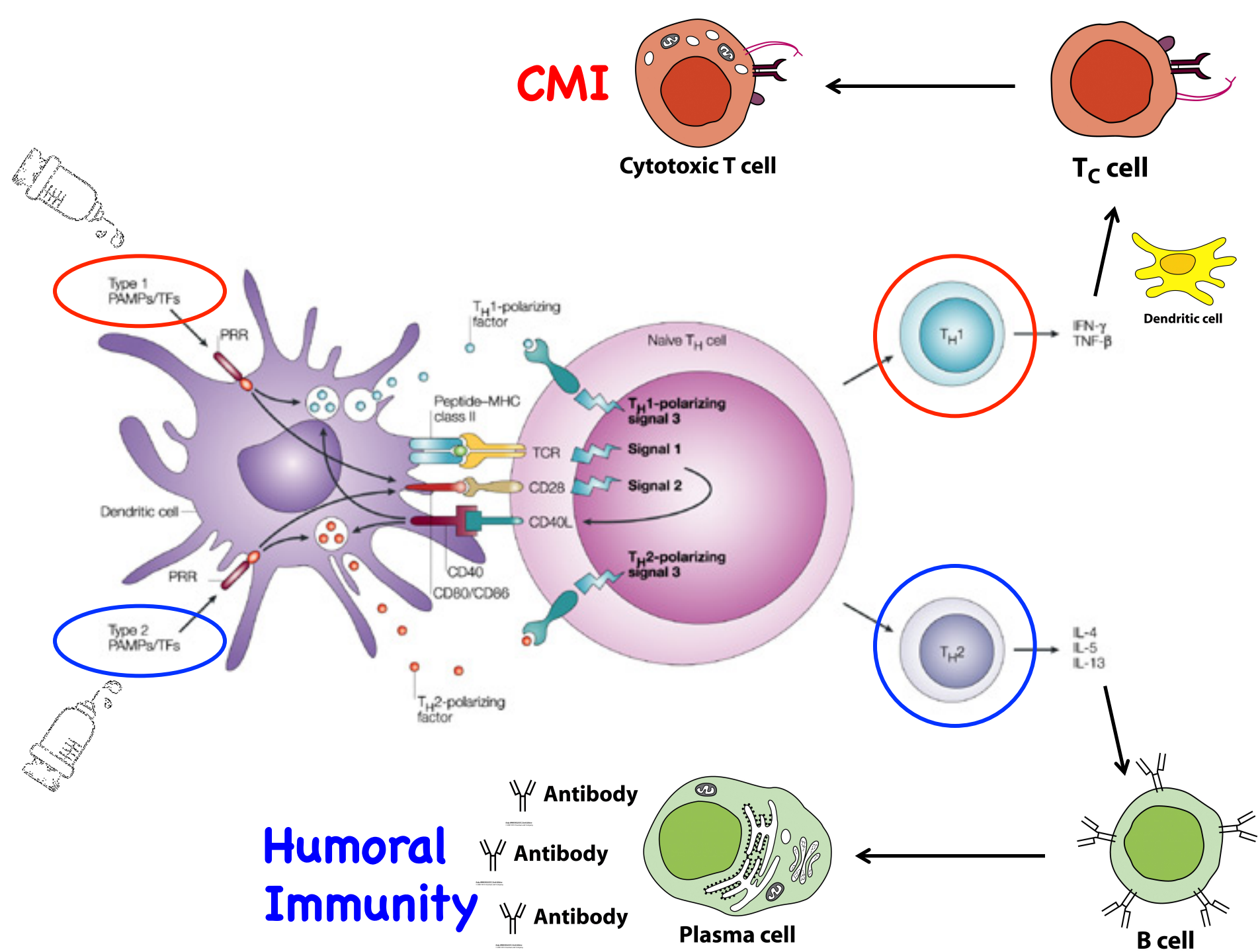
**Antibody**

**Antibody**

**Plasma cell**

**B cell**

**Humoral  
Immunity**



# Vaccination vs. Immunization

- Immunization is the process of eliciting a robust, specific, and long-lasting response against any given antigen.
- **Passive immunization:** transfer of some immune system elements (Abs or cells) to a living body
- **Active immunization:** induction of immune response against a specific antigen (**Vaccination**)

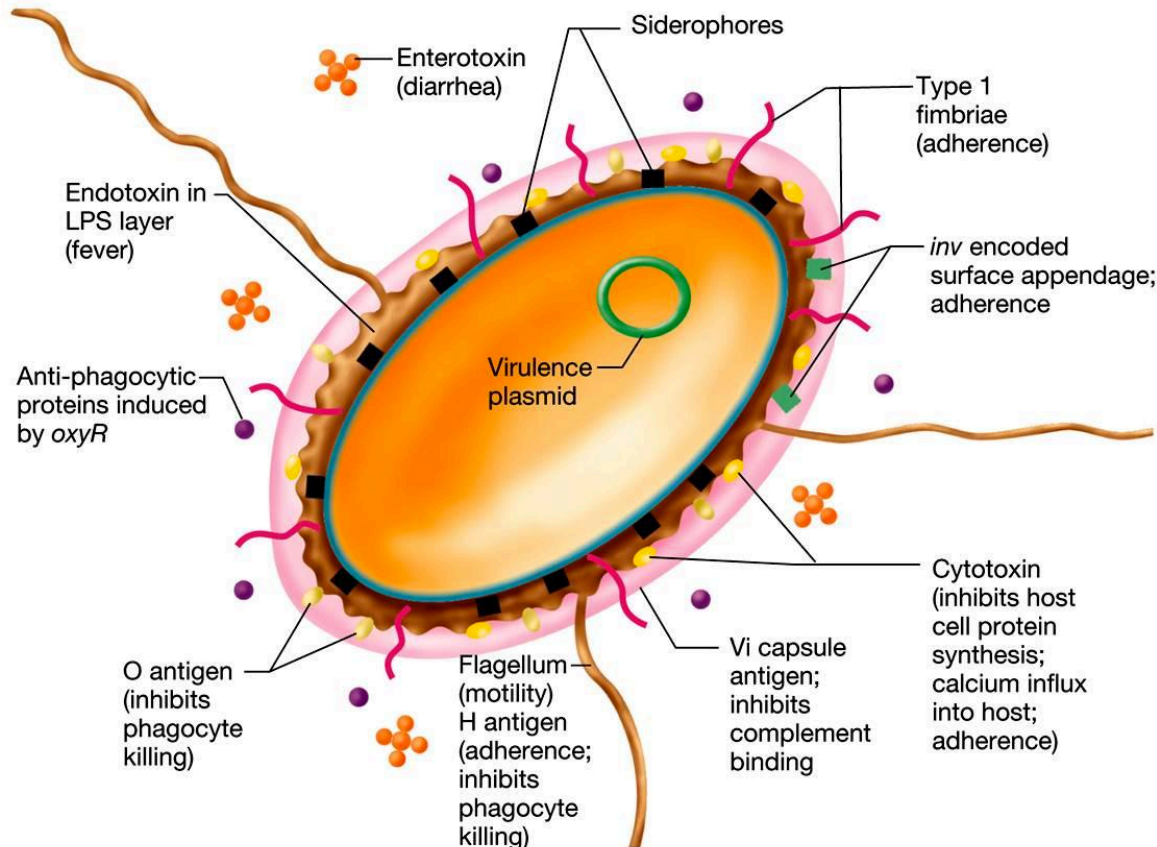


# Major effects of vaccines

- ① Vaccines protect individuals against diseases
- ② Prevents the transmission of infections if there are sufficient immune individuals. This effect is known as Herd Immunity

# Virulence factors

- Virulence factors include the molecules that allow a microorganism to be a pathogen.

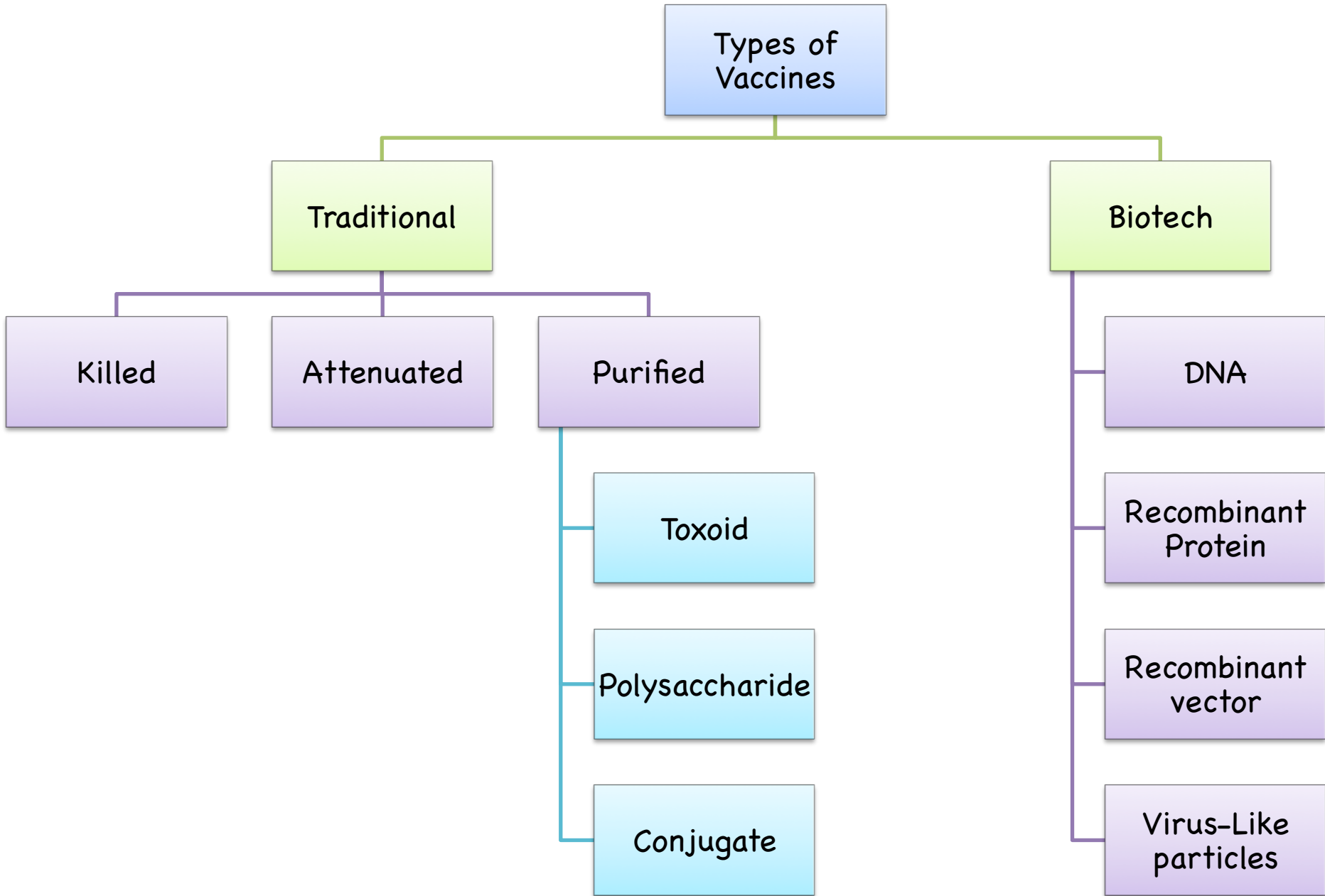


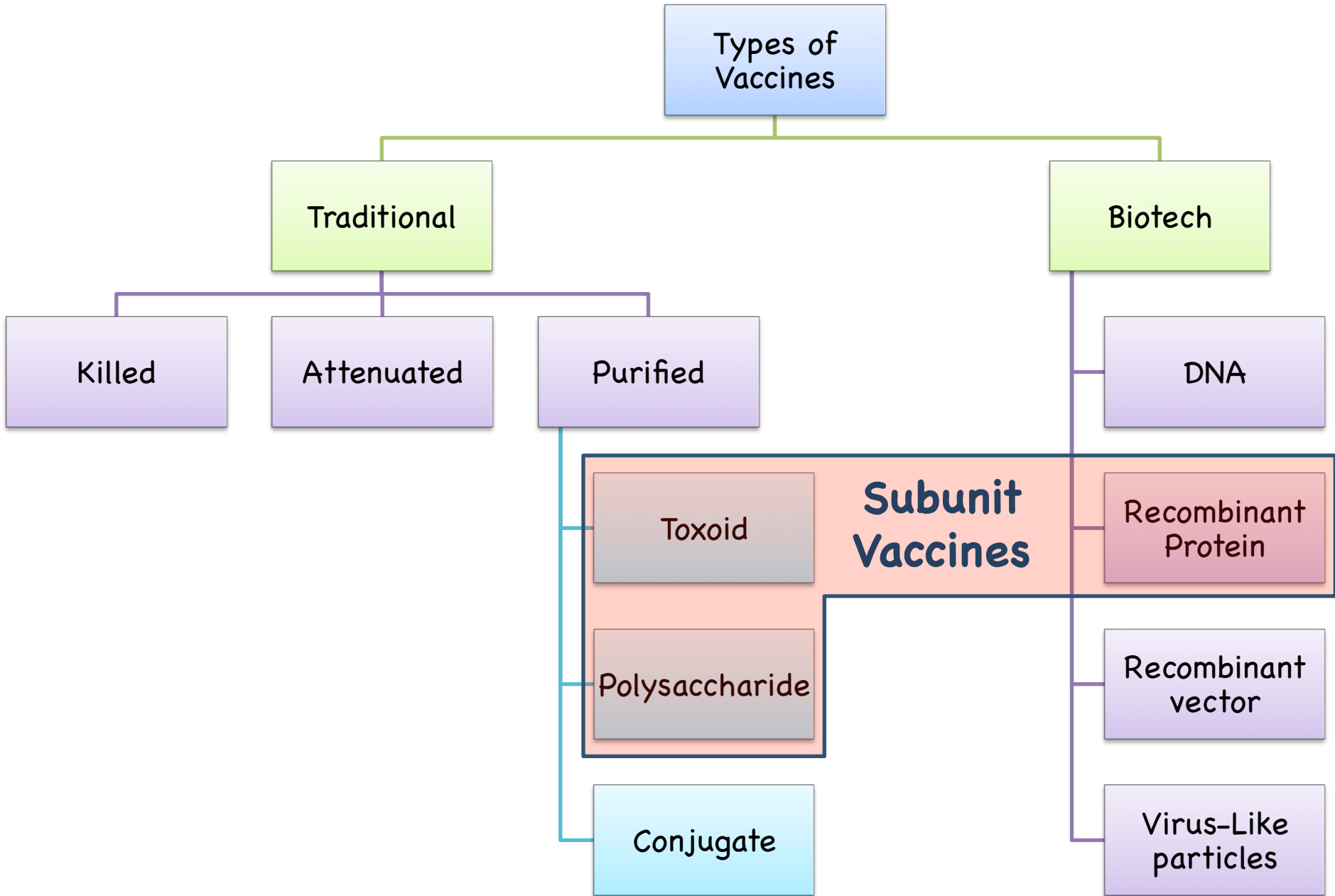
# Exotoxin vs. Endotoxin

Property	Exotoxin	Endotoxin
Chemistry	Secreted proteins	Shed lipopolysaccharide
Source	Gram (+ve) or Gram (-ve) bacteria	Gram (-ve) bacteria
Symptoms	Specific action on target tissue	Fever, diarrhea, vomiting, shock
Toxicity	High / Fatal	Weak / Rarely fatal
Immunogenicity	Causes neutralizing Ab production	Insufficient Ab production
Toxoid potential	After formaldehyde treatment	None
Fever potential	Rarely	Pyrogenic

# The Ideal Vaccine

- ① 100% efficient in all individuals of any age
- ② Induce the correct type of immunity
- ③ Provides life-long protection after single administration
- ④ Does not evoke adverse reactions or cause diseases
- ⑤ Physically stable under various conditions (temp., light, transportation)
- ⑥ Genetically stable
- ⑦ Easy to administer (orally vs. parenterally)
- ⑧ Available in unlimited quantities
- ⑨ Affordable (<\$1, WHO)





# Traditional Vaccines

## 1. Non-living whole organism

Heat inactivated or chemically inactivated

## 2. Live attenuated organism

Bacteria or viruses attenuated in culture

## 3. Purified Macromolecules

Extraction and purification of pathogen components

- Toxoid
- Polysaccharide
- Conjugate

# Non-Living Whole Organism

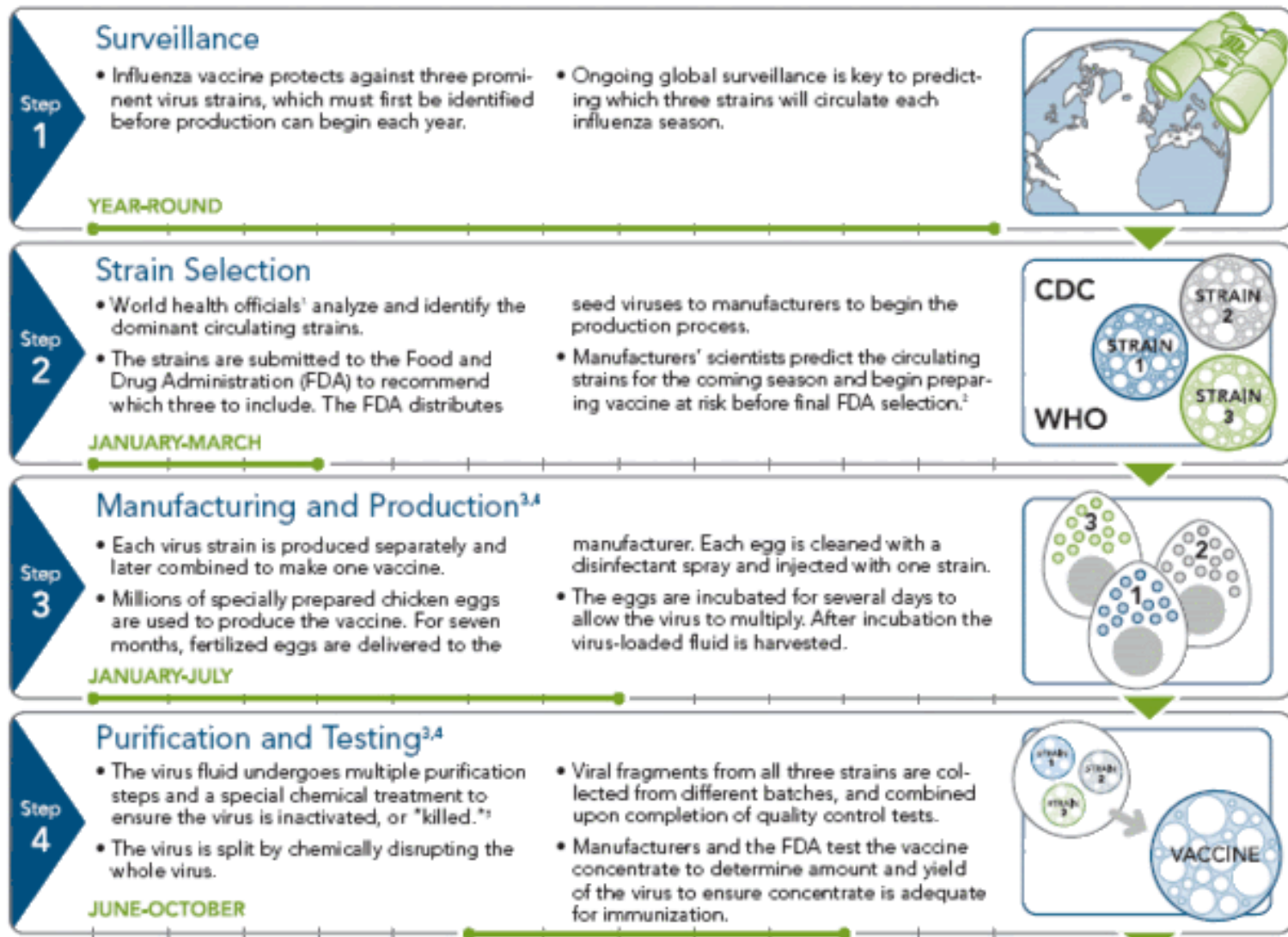
- The pathogen raises an immune response but not capable of replication in the host "lost virulence factors"
- Produced by heat or formaldehyde inactivation "killing" of a pathogen



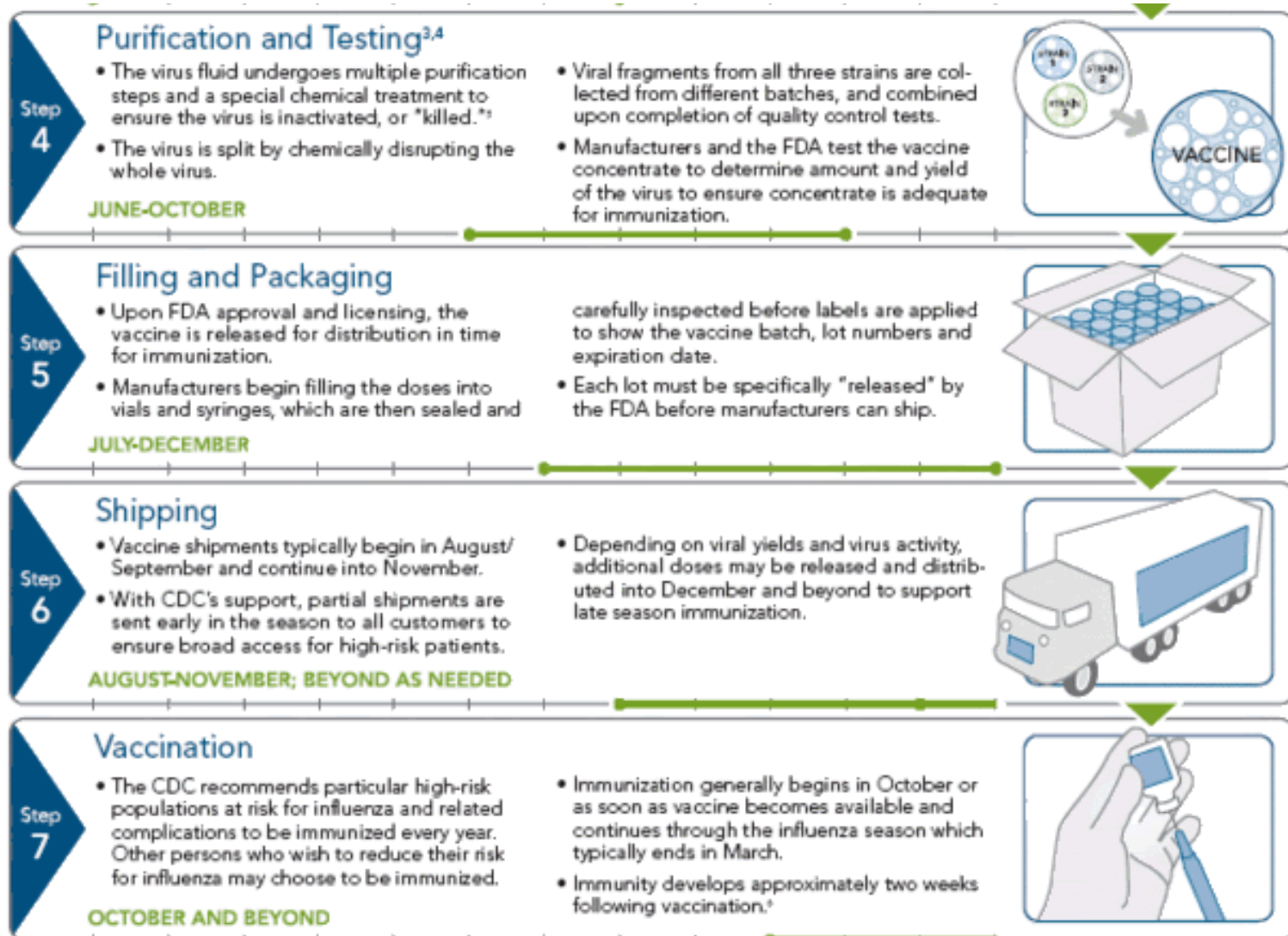
# Non-Living Whole Organism

Disease		Remarks	Effectiveness
Viruses	Polio	(Salk polio) safe in immunocompromised	Very effective
	Rabies	Can be given post exposure	Very effective
	Influenza	Strain specific	Moderately effective
	Hep. A	Also attenuated vaccine	Very effective
Bacteria	Pertussis	Controversial toxicity	Very effective
	Typhoid	About 70% protection	Moderately effective
	Cholera	Protection dubious	Moderately effective
	Plague	Short-term protection	Debatable

# Flu vaccine production



# Flu vaccine production



# Live Attenuated Organism

- Attenuation means “reducing virulence” while maintaining the capability of transient growth and immunogenicity
- Can be produced by passing the microbe through unnatural host, unnatural media, or exposure to harsh chemical for a long period

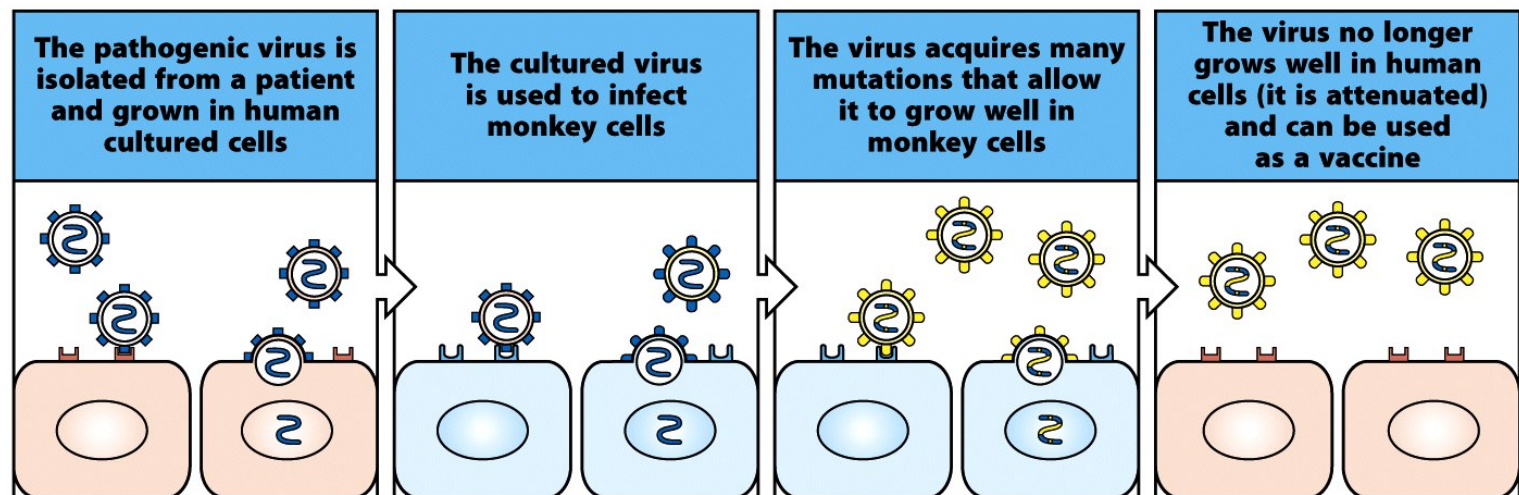


Figure 15-29 Immunobiology, 7ed. (© Garland Science 2008)

# Live Attenuated Organism

- Attenuated vaccines elicit a vigorous long-lasting immune response from a single dose
- They can induce cell-mediated immune response
- Attenuated pathogens can mutate and revert virulent forms
- *Rational attenuation*

# Live Attenuated Organism

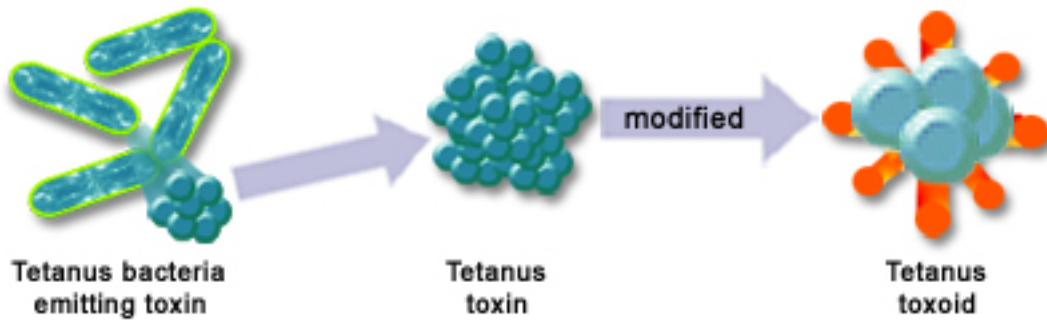
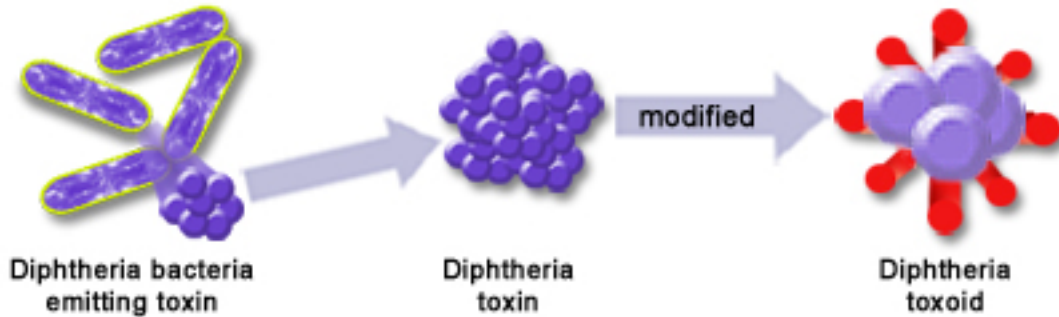
Disease		Remarks
Viruses	Polio	(Sabin polio) safe in immunocompromised
	Measles	80% effective
	Mumps	
	Hep. A	Also killed vaccine
Bacteria	Tuberculosis	BCG vaccine

# Toxoid

- Modified bacterial exotoxins. Toxins treated with iodine, pepsin, ascorbic acid, or formalin to reduce toxicity while retaining immunogenicity
- Toxoids generate neutralizing antibodies
- Diphtheria toxoid, tetanus toxoid

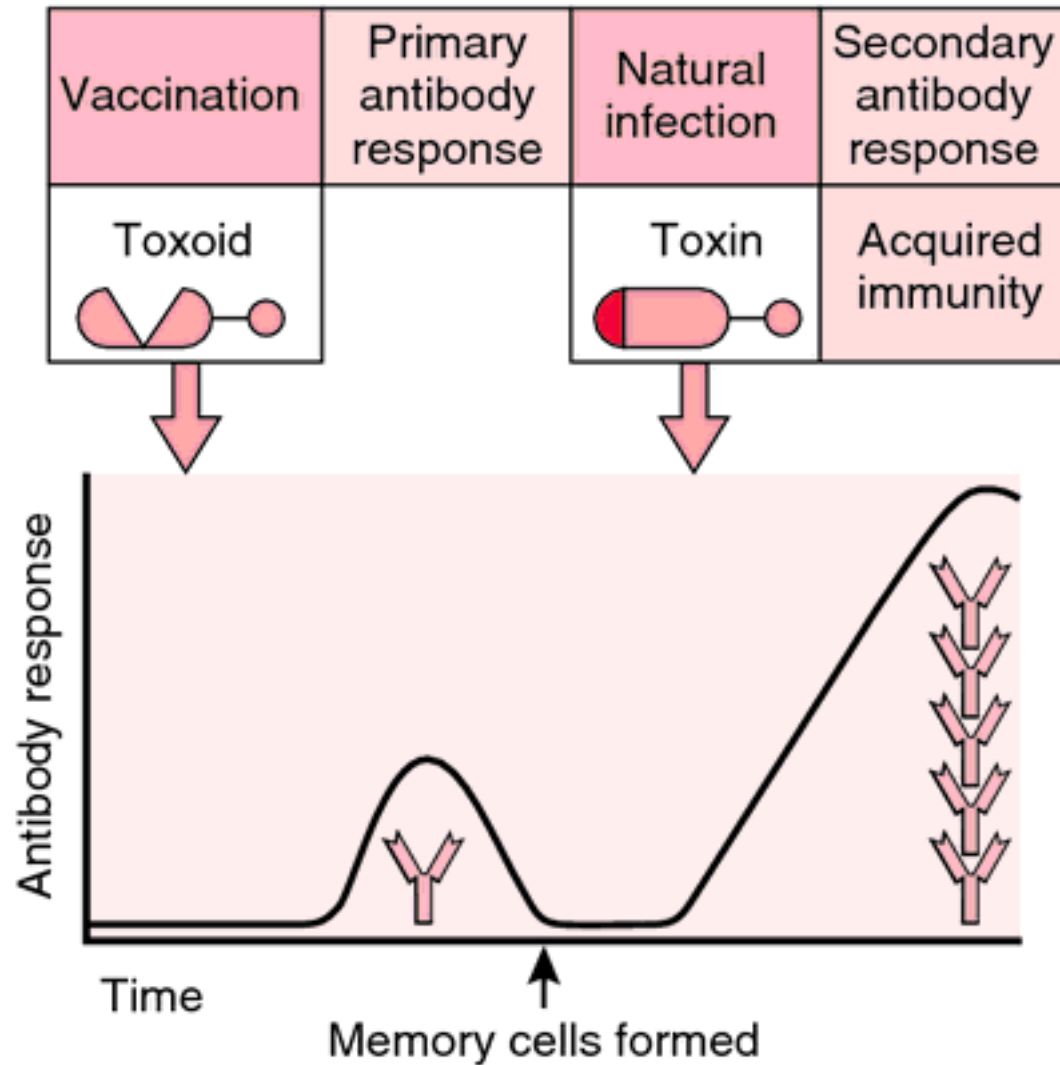


# Toxoid





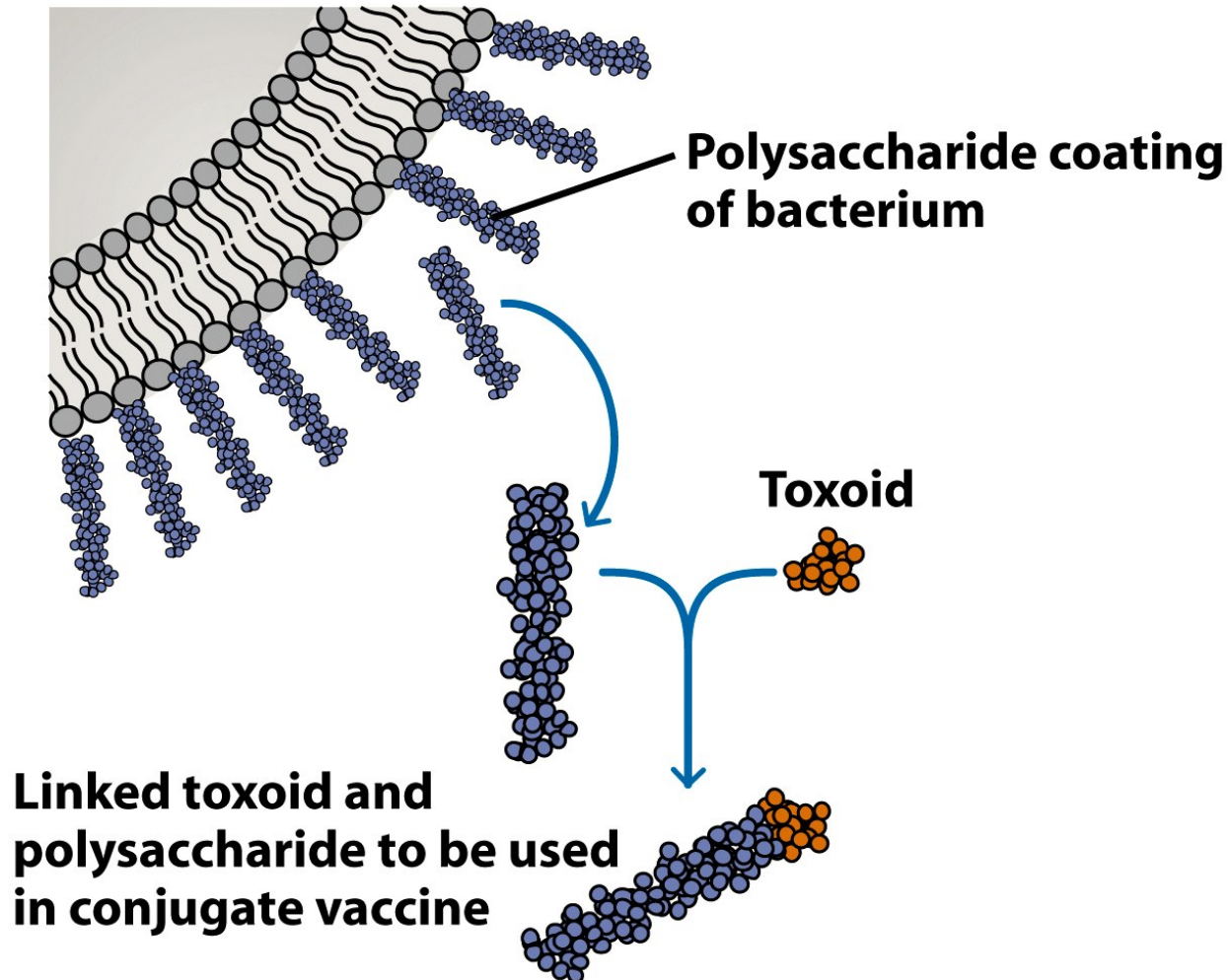
# Toxoid



# Conjugate

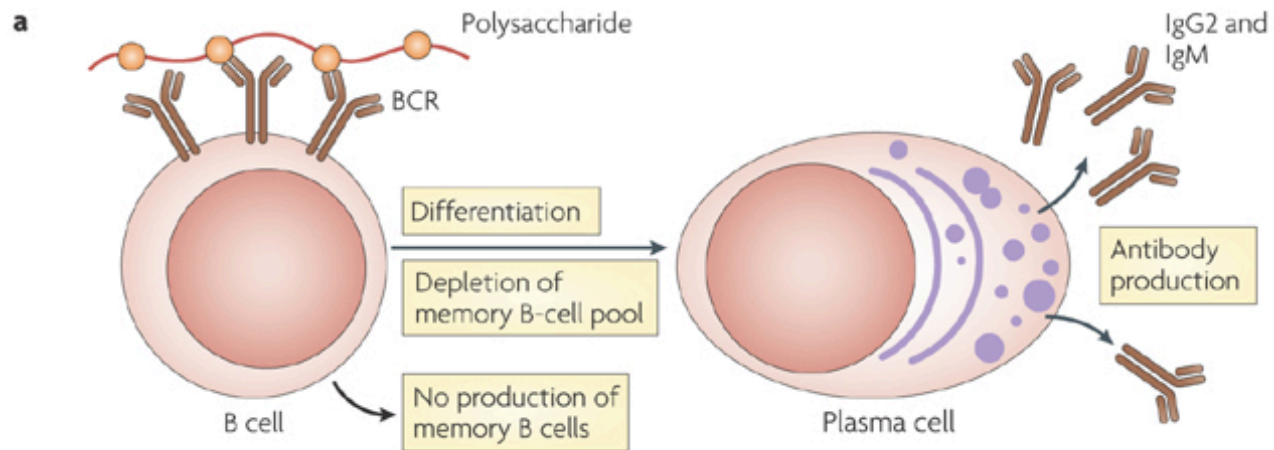
- Polysaccharide capsule conjugated with toxoid to stimulate CD4<sup>+</sup> cells and generate memory cells
- HiB (+tetanus toxoid), PCV (+diphtheria toxoid)

# Conjugate

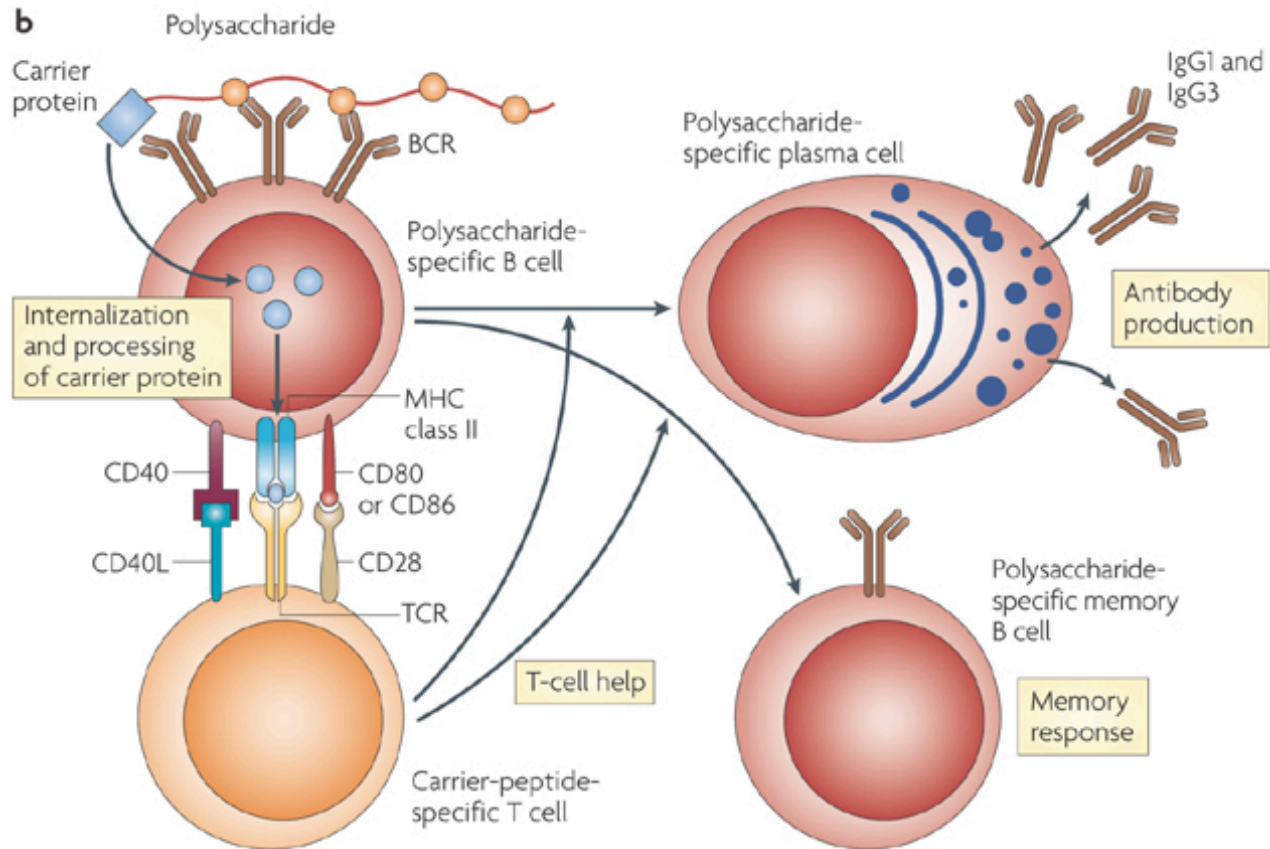


**Figure 19-5a**  
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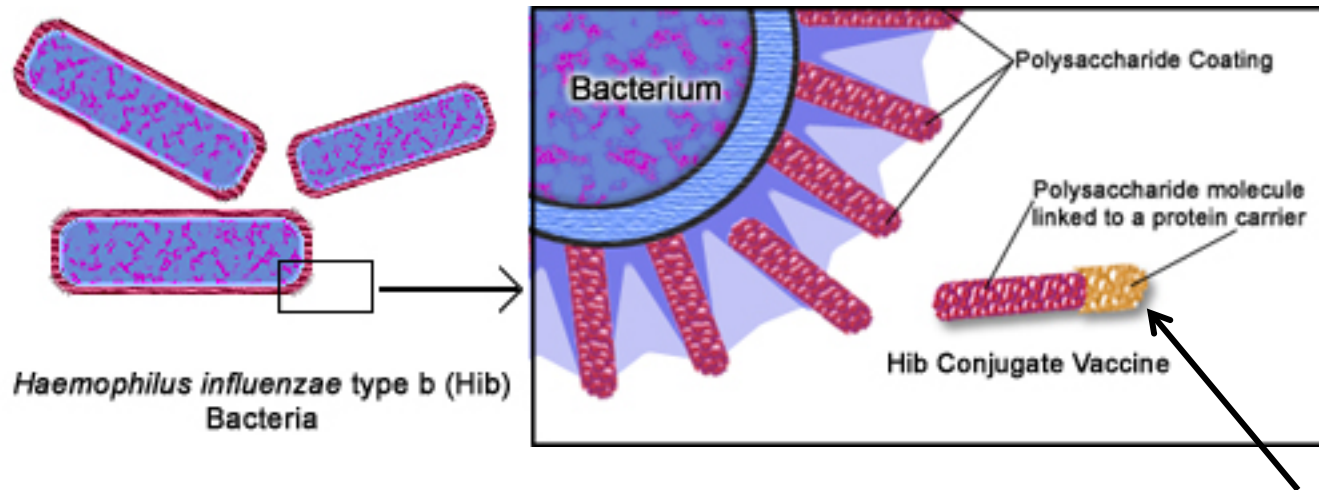
# Conjugate



# Conjugate

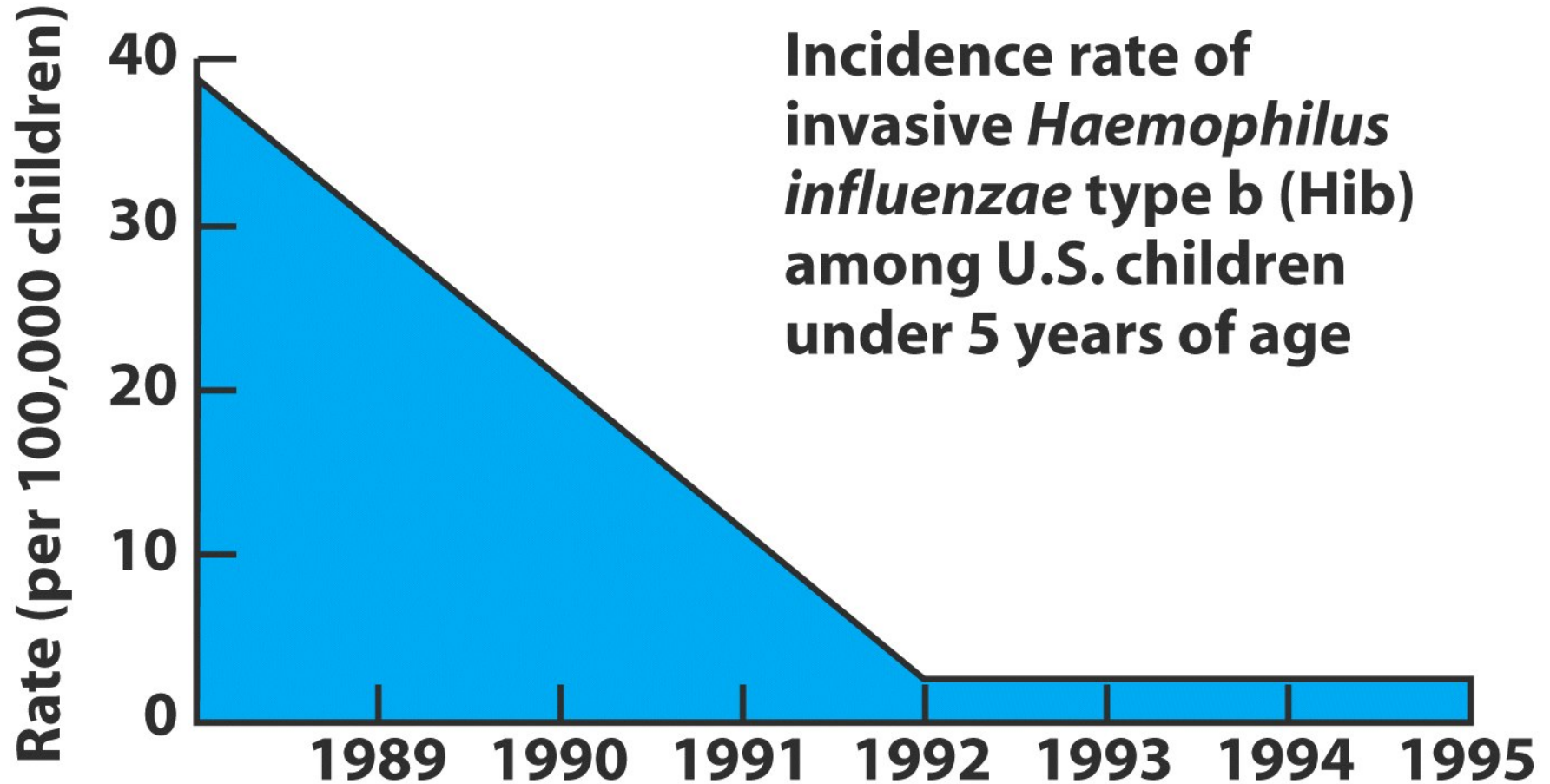


# Conjugate



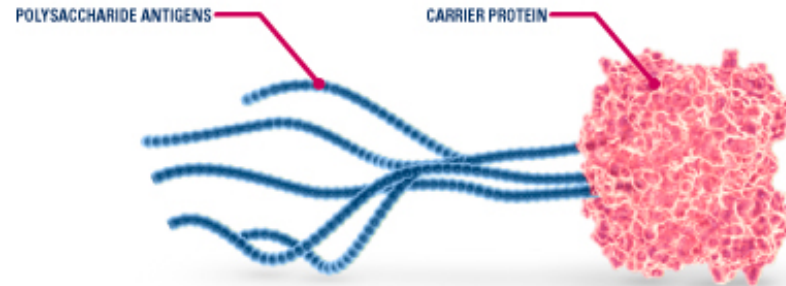
tetanus toxoid

# Conjugate





# Conjugate



Prenar 13<sup>®</sup>, comprising polysaccharide antigens conjugated to a carrier protein, elicits a **T cell-dependent** immune response





**You are now able to:**

- ✓ Realize the significance of immunization
- ✓ Describe how vaccines work
- ✓ Distinguish between different types of vaccines