Vaccine: A vaccine is an antigenic material that stimulate adaptive immunity to a disease. Vaccines can prevent the effects of infection by many pathogens.

Variolation (inoculation) was the method first used to immunize an individual against smallpox (*Variola*) with material taken from a patient or a recently variolated individual, in the hope that a mild, but protective, infection would result.

Vaccination (Latin: *vacca* mean cow) is named because the first vaccine was derived from a virus affecting cows, the relatively benign cowpox virus, which provides a degree of immunity to smallpox, a contagious and deadly disease.

Variolation	Vaccination
Variolation is a method of immunization where administration of live viruses takes place against a viral infectious agent	Vaccination is a method of immunization where administration of an attenuated virus takes place against a viral infectious agent
Form of immunization: live smallpox virus	Form of immunization: attenuated viruses, DNA vaccine or edible vaccine
Example: Smallpox vaccine	Examples: Hepatitis, Malaria, Rubella, etc.

Immunization is the process whereby a person is made immune or resistant to an infectious disease, typically by the administration of a vaccine. Vaccines stimulate the body's own immune system to protect the person against subsequent infection or disease.

The aim of immunization:

1- The prevention of disease in individuals or groups.
2- Protection of individuals against symptoms, ex: Diphtheria, Tetanus are for example anti-disease rather than antimicrobial vaccines.

Characters of vaccine (properties of ideal vaccine)

Vaccines must fulfill several, criteria to be effective in protecting large numbers of individuals:

1- It is **highly immunogenic**, so that a single vaccine dose provide a complete immunization regimen.
2- The recommended vaccine regimen is highly efficacious in **preventing disease** in individual vaccine recipients.
3- It has **long duration of immunity** so that frequent booster doses are not needed.
4- It **limits spread of infection**, because it prevents vaccine recipients from spreading infection to other people.
5- It is **heat stable**, so that refrigeration is not required during shipping and storage.
6- **Injection is not required** for administration, e.g. nasal spray of vaccine can be used.
7- It can safely be administrated simultaneously with other vaccine either as a part of specific combination vaccine (measles-mumps-rubella) or a separate individual vaccine.
8- **Adverse effect in vaccine recipients are few**, **non-sever, and temporary**, (the microbe used to prepare the vaccine does not cause disease in recipient who have weakened immune system from HIV infection, severe malnutrition, malignancies, or congenital immunodeficiency).
9- The **microbe** used to prepare the vaccine **never reverts to wild type** or otherwise mutates to cause dieses, new mutant forms might arise that could evade the immune system and produce disease, new vaccinated individuals.
10- It is technically **simple to manufacture**, so that it can be produced in less sophisticated settings.
11- It is **inexpensive** to manufacture, distribute and administer, so that it is affordable by the maximum number of people.

Routs of Administration

1- Subcutaneous or intramuscular rout (most vaccines).
2- Oral routs (Sabin, oral BCG).
3- Intradermal (BCG).
4- Scarification (Smallpox).
5- Intranasal (live attenuated influenza vaccine).

Scheme of immunization:

Primary vaccination:

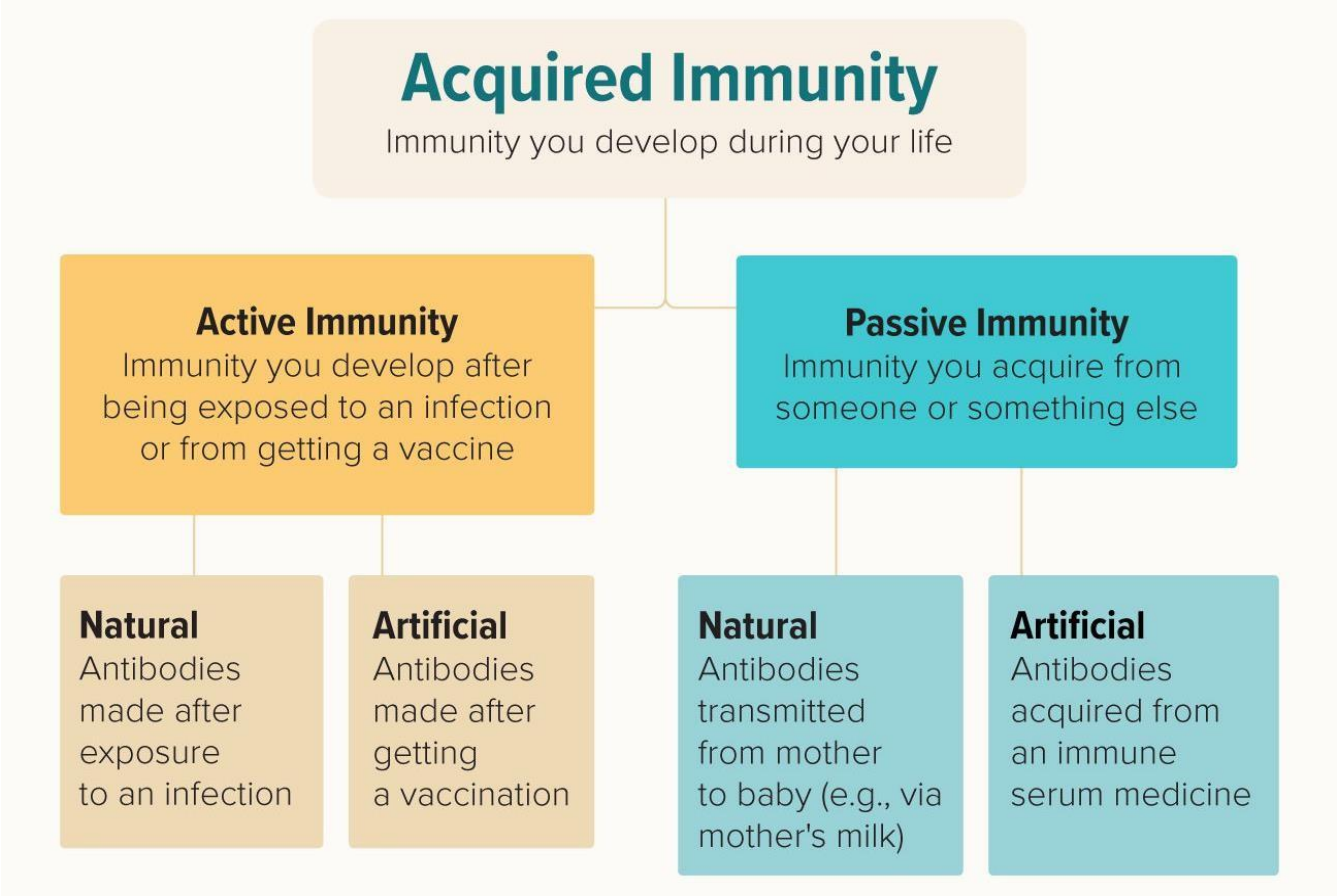
- One dose vaccines (BCG, Variola, Measles, Mumps, Rubella, Yellow fever).
- Multiple dose vaccines (Polio, DPT, Hepatitis B).

Booster vaccine:

- To maintain immunity level after its declines after some time has elapsed.

TYPES OF IMMUNITY

Immunity divided into 2 types: Innate immunity and Acquired immunity figure 2.



Types of Vaccines

There are two basic types of vaccines: live attenuated and inactivated. The characteristics of live and inactivated vaccines are different, and these characteristics determine how the vaccine is used.

1-Live attenuated vaccines

Live attenuated vaccines are produced by modifying a disease-producing (wild) virus or bacterium in a laboratory. The resulting vaccine organism retains the ability to replicate (grow) and produce immunity, but usually does not cause illness.

Table 1. Live attenuated vaccines

Bacteria/Virus	Vaccine	Method	Rout
Vibrio cholera	CVD103 hgr	Generally modified	Oral
Salmonella	Ty21a	Generally modified	Oral
Mycobacterium	BCG	Prolog subculture	ID
Polio	Sabin	Passage in monkey kidney cells	Oral
Yellow fever	17D	Passage in chick embryo cell	SC
Influenza		Temperature sensitive mutant	IN
Measles	MMR	Passage in fibroblast cells	SC
Rubella	Wistar	Wister institute (RA 27/3 strain of atten. Virus)	SC
Chickenpox	Oka/merck	Human diploid cell cultures	SC
Smallpox	Vaccinia	Naturally a virulent	ID

Advantage

1- Infectious microbe can stimulate generation of memory cellular as well as humeral immune response.

2- Multiple booster dose may not be required.

3- Some live vaccines can be given orally to induce mucosal immunity and IgA synthesis.

Disadvantage

1- May very rarely revert to its virulent form and cause disease.

2- Live vaccines cannot be given safely to immunosuppressed individual.

2-Killed vaccines

Killed or inactivated organisms are used where attenuation has not been achieved, the reversion to wild type occurs too easily.

These vaccines include organisms that are dead because of the treatment with physical or chemical agents. In the case of toxins, they will have been inactivated (toxoid). They should be incapable of infection, replication, or function but still able to provoke immunity.

Table 2. Killed or inactivated vaccines

Bacteria/virus	Vaccine	Method	Rout
Vibrio cholera	CVD103 hgr	Phenol	SC or ID
Salmonella typhi	TAB	Heat, phenol, acetone	SC
Yersinia pestis	Haffkine	Formalin	SC
Bordetella pertussis	Sabin	Merthiolate	IM
Poliomyelitis	Salk	Formalin	IM
Rabies virus	Semple	Phenol	SC
Influenza virus	MMR	Formalin	IM
Hepatitis A	HM175	Formalin	IM

Advantage

1- Safe to use and can be given to immunodeficient and pregnant woman.

2- Cheaper than live attenuated vaccine.

3- Storage not are critical as live vaccine.

Disadvantage

1- Since the microorganism cannot multiply, a large number are required to stimulate

immunity.

2- Only humoral immunity can be induced.
3- Inactivated such as formaldehyde may alter immunogenicity.

3- Toxoid

Bacterial toxins inactivated (usually by formaldehyde) so that they are no longer toxic but still induce protective antibodies.

For example, the tetanus toxoid is derived from the tetanospasmin produced by *Clostridium tetani*.

Vaccination schedule in Iraq

- **At birth:** BCG, OPV-0, HBV-1
- **2 months completed:** pentavalent vaccine (DTP-1, Hib1, and HBV-2), OPV1 and Rotavirus1.
- **4 months completed:** quadruple vaccine (DTP-2, and Hib2) OPV2 and Rotavirus2.

- **6 months completed:** pentavalent vaccine (DTP-3, Hib3, and HBV-3), OPV3 and Rotavirus3.
- **9 months completed:** measles
- **15 months completed:** MMR1
- **18 months completed:** Quadruple vaccine (DTP, and Hib) OPV. (booster no.1)
- **4-6years:** DTP, OPV (poster no.2) and MMR2

1- Bacilli calmette-guerin (BCG) vaccine

The live attenuated strain of *mycobacterium bovis* known as bacillus Calmette-Guerin (BCG) uses shared antigens to stimulate the development of cross-immunity to *Mycobacterium tuberculosis*. It lost its virulence in humans by being specially cultured in an medium for years.

Benefit:

1- Prevention of *tuberculosis*.
2- BCG prevents dissemination of the bacterium or the development of other life-threatening complications such as meningitis.
3- BCG is effective at reducing morbidity and mortality in children but is less useful in the prevention of adult respiratory disease.

Route of administration:

- **BCG** is given as a **single** intra-dermal injection at the insertion of the deltoid into the lateral aspect of the left upper arm.
- The insertion of deltoid is most frequently used because the local complication rate is smallest when that site is used.

Adverse effects:

1- Local ulceration and regional suppurative adenitis occur in 0.1-1 % of vaccine recipients.
2- If BCG is accidentally given to an immunocompromised patient, it can cause disseminated or life threatening infection

2- Polio vaccines

Poliovirus: Enterovirus (RNA), three serotypes: 1, 2, 3, Human is the reservoir, transmission by fecal-oral or possible oral-oral, communicability 7-10 days before onset, the virus present in stool for 3-6 weeks. viral spread along nerve fibers leads to destruction of motor neurons.

The two vaccines have eradicated polio from most of the countries in the world from an estimated 350,000 cases in 1988 to less than 2000 cases in 2008 and to 359 in 2014.

Salk's polio vaccine "inactivated polio vaccine" IPV

3- DPT vaccine

Diphtheria

- Caused by aerobic gram-positive bacillus; *Corynebacterium diphtheria*
- complication are myocarditis and neuritis, death occurs in 5-10% for respiratory illness

Tetanus

- Caused by anaerobic gram-positive spore-forming bacteria; *Clostridium tetani*
- Complications:- laryngospasm, aspiration pneumonia, and death.

Pertussis

- Highly contagious respiratory infection caused by *Bordetella pertussis*
- Complication :- pneumonia, seizures, encephalopathy.

DPT: mixture of three vaccines, to immunize against diphtheria, pertussis and tetanus

Pertussis, whole heat or formalin killed vaccine with Diphtheria and Tetanus toxoid

DPT administered in a dose of 0.5 ml intramuscularly five vaccinations

before age 7 years (at 2,4,6, and 15-18 month and at 4-6 years)

4-MMR vaccine

Measles

caused by *paramyxovirus* (RNA); Complication: diarrhea, otitis media, pneumonia

Mumps

caused by *paramyxovirus* (RNA); Complication: CNS involvement, deafness

Rubella

caused by *togavirus* (RNA); Major concern is **congenital rubella syndrome** as up to 85% of infants affected during first trimester when placenta and fetus infected during viremia; infection may affect all organs, may lead to fetal death or premature delivery, deafness, liver and spleen damage.

MMR vaccine: composed of three live attenuated vaccines (Measles, Mumps & Rubella)