Virology

Lec (5)

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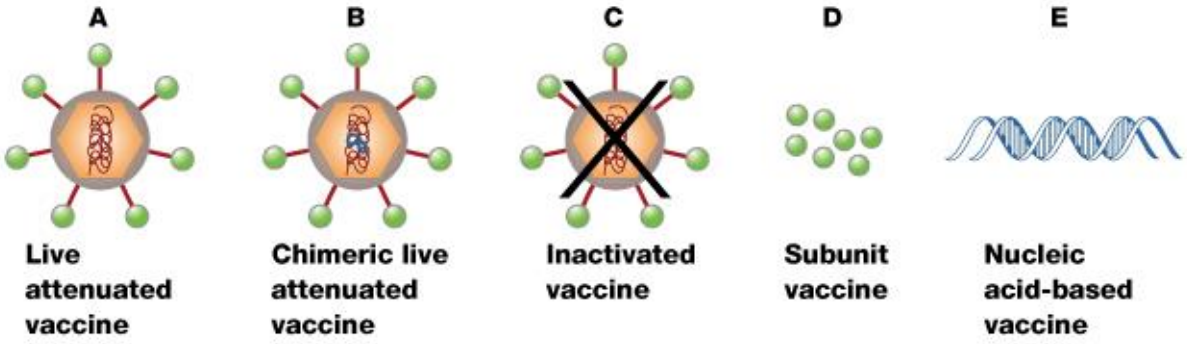
Teaching Objectives:

1. To recognize types of vaccine.
2. To distinguish advantage and disadvantage of each type.
3. To recognize the mechanism of action.

Viral vaccine

Prevention of viral disease can be achieved by the use of vaccines that induce active immunity or by the administration of performed antibody that provides passive immunity.

Types of vaccines there are three basic types of vaccine (conventional vaccine methods) are use today.



1-Live vaccines: These are live virus particles that grow in the vaccine recipient but do not cause disease because the vaccine virus has been altered (mutated) to a non-pathogenic form.

A-Live attenuated vaccines: Viruses whose virulence has been artificially reduced by in vitro cell culture under adverse conditions, such as reduced temperature. Following administration, replication of the vaccine strain occurs without causing clinical disease, like influenza virus vaccine.

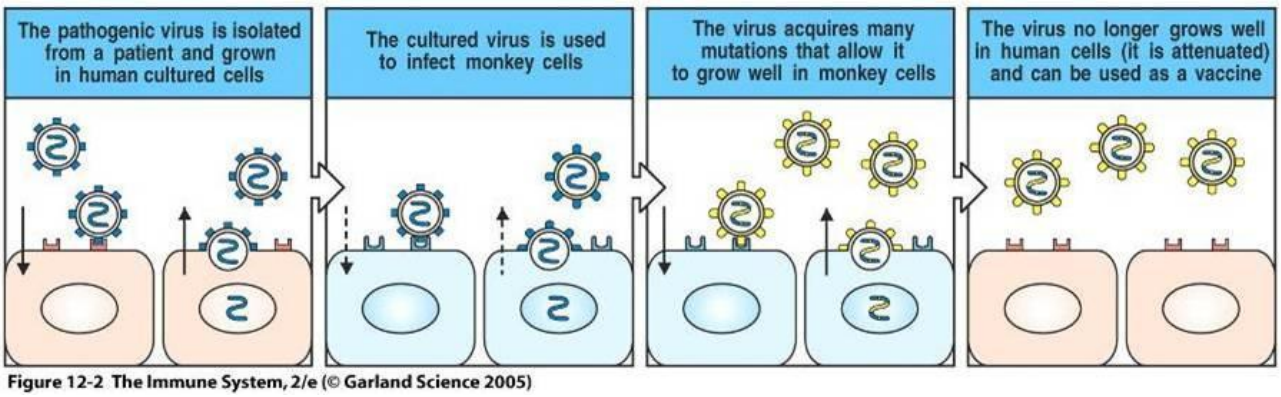


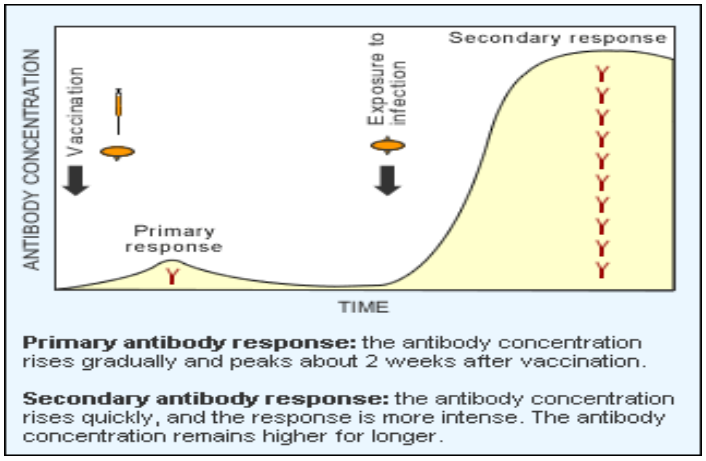
Figure 12-2 The Immune System, 2/e (© Garland Science 2005)

B-Heterologous vaccines: Closely related virus of lesser virulence, which shares many antigens with the virulent virus. Following exposure, the vaccine strain replicates in the host and induces immune responses that cross reacts with antigens of the virulent virus. The most important example of this type of vaccine is vaccinia virus: both cowpox virus and vaccina virus are closely related to variola virus, the causative agent of small pox. Edward Jenner observed that milkman who had been infected with cowpox virus were immune to smallpox.

C-Live recombinant vaccines: This type of vaccine prepared by using genetic engineering to introduce a gene coding for an immunogenic protein from one virus into the genome of another, such as vaccinia virus. Following injection into the subject, the recombinant virus will replicate and express sufficient amounts of the foreign protein to induce a specific immune response.

2-Killed or inactivated vaccine: These are prepared from normal (wild type) infectious, pathogenic virus that has been rendered non-pathogenic, usually by chemical treatment such as formaldehyde that cross-links viral protein or by propiolactone. These vaccines are not infectious and are therefore relatively safe.

Characteristic	Live vaccine	Killed vaccine
Number of doses	Single	Multiple
Effectiveness of protection	Greater	Lower
Duration of immunity	Longer	Shorter
Cell-mediated immunity	Yes	Weak or none
Immunoglobulin produced	IgA, IgG	IgG
Stability at room temperature	Low	High
Need for adjuvant	No	Yes
Cost	Low	High
Reversion to virulence	Possible	No
Interference	Occasional OPV	No
Side effect	Mild symptoms	Sore arm



3-Sub-unit vaccines: These are purified components of the virus, such as a surface antigen. These vaccines are safe and fewer local reactions occur at the injection site.

A-Advantages of sub-unit vaccines:

- They have no viral nucleic acid, so cannot replicate or revert to virulence.
- They have no contaminating viruses from cell culture.
- They can be produced in large amounts.

B-Disadvantages of sub-unit vaccines:

-They are unlikely to stimulate a cytotoxic T cell response because no viral replication occurs.

Passive immunity:

Passive immunity is provided by the administration of performed antibody in preparation called immuneglobulin.

1-Rabies immune globulin (RIG) is used in the prevention of rabies in people who may have been exposed to the virus. It is administered by injecting as much RIG as possible into the tissue at the bite site and the remainder is given intramuscularly.

2-Hepatitis B immune globulin (HBIG) is used in the prevention of hepatitis B in people who may have been exposed to the virus either by needle-stick or as a neonate born of a mother who is a carrier of HBV. The preparation contains a high titer of antibody to hepatitis B virus and is obtained from human to avoid hypersensitivity reactions. HBIG is often used in conjunction with hepatitis B vaccine, an example of passive - active immunization.

3-Varicella-zoster immune globulin (VZIG) is used in the prevention of disseminated zoster in people who may have been exposed to the virus and who are immunocompromised, the preparation contains a high titer of antibody to varicella-zoster virus and is obtained from humans to avoid hypersensitivity reaction.

4-Vaccinia immune globulins (VIG) can be used to treat some of the complications of the small pox vaccination.

5-Immune globulins (IGs) are useful in the prevention of hepatitis A or measles in people who may have been exposed to these viruses. IGs are commonly used prior to traveling to areas of the world where hepatitis A virus is endemic. IGs contain pooled serum obtained from a large number of human volunteers who have not been hyperimmunized.

New methods of vaccines

Nucleic acid vaccines use genetic material from a disease-causing virus or bacterium (a pathogen) to stimulate an immune response against it. Depending on the vaccine, the genetic material could be DNA or RNA; in both cases it provides the instructions for making a specific protein from the pathogen, which the immune system will recognise as foreign (an antigen). Once inserted into host cells, this genetic material is read by the cell's own protein-making machinery and used to manufacture antigens, which then trigger an immune response.

This is a relatively new technology, so although DNA and RNA vaccines are being developed against various diseases, including HIV, Zika virus and COVID-19, so far none of them have yet been approved for human use. Several DNA vaccines are licenced for animal use, including a horse vaccine against West Nile virus

- Immune response involves B cells and T cells
- No live components, so no risk of the vaccine triggering disease

- Relatively easy to manufacture
- Some RNA vaccines require ultra-cold storage
- Some of them not licensed in humans
- Booster shots may be required

How do nucleic acid vaccines trigger immunity?

In the case of DNA vaccines, a piece of DNA encoding the antigen is first inserted into a bacterial plasmid. This is a circular piece of DNA used by a bacterium to store and share genes which may benefit its survival – a bit like a computer flash drive. Plasmids can replicate independently of the main chromosomal DNA and provide a simple tool for transferring genes between cells. Because of this, they are already widely used within the field of genetic engineering.DNA plasmids carrying the antigen are usually injected into the muscle, but a key challenge is getting them to cross into people's cells. This is an essential step, because the machinery which enables the antigen to be translated into protein is located inside cells.

Various technologies are being developed to aid this process - such as electroporation, where short pulses of electric current are used to create temporary pores in patients' cell membranes; a 'gene gun' which uses helium to propel DNA into skin cells; and encapsulating the DNA in nanoparticles which are designed to fuse with the cell membrane.

RNA vaccines encode the antigen of interest in messenger RNA (mRNA) or self-amplifying RNA (saRNA) – molecular templates used by cellular factories to produce proteins. Because of its transitory nature, there is zero risk of it integrating with our own genetic material. The RNA can be injected by itself, encapsulated within nanoparticles (as Pfizer's mRNA-based Covid vaccine is), or driven into cells using some of the same techniques being developed for DNA vaccines.

Once the DNA or RNA is inside the cell and it starts producing antigens, these are then displayed on its surface, where they can be detected by the immune system, triggering a response. This response includes killer T cells, which seek out and destroy infected cells, as well as antibody-producing B cells and helper T cells which support antibody production.