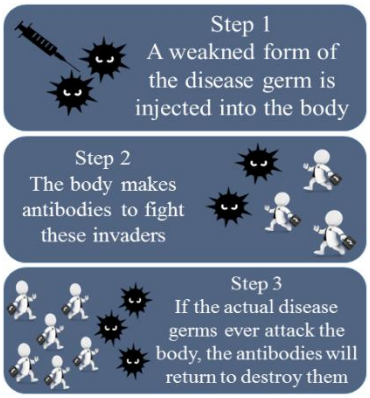
VACCINES

What are vaccines?

A vaccine is a biological preparation used to produce or improve immunity against a particular disease. By inoculating killed or weakened disease-causing microorganisms (or crucial fragments, products or derivatives) the production of antibodies is stimulated. If and when the immune system encounters the disease-causing microorganism, it then itself prevents the disease from reacting rapidly and effectively.

How do vaccines work?

When the germs attack our body, they cause an infection; their surfaces are made up of molecules with a different and unique marker called **antigens**, so the immune system can recognize the microbes and fight against them. Macrophages attack and digest most parts of them, saving the antigens and carry them to the lymph nodes, where lymphocytes B produce protein substances called **antibodies** and highly specific cells that can fight the invading germs.
The goal of most vaccines is to stimulate the antibodies response because it provides the protection against the specific disease. If a person later is exposed to that same pathogen again, the immune system will be able to produce the same type of antibodies.



Picture made by Susanna Gobbi

How are vaccines produced?

Biotechnology is used in three different ways in the development of vaccine:

1. Use of monoclonal antibodies for immunopurification of antigens: this method is used to separate specific antigen from a mixture of very similar antigens. Once purified, the antigen is used for developing a vaccine against a pathogen. Individual interferons (which have the property of inhibiting viral infection and cell proliferation) have been purified using this technique.

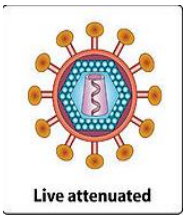
2. Use of cloned genes for the synthesis of antigens: hundreds of genes in eukaryotes have been cloned from genomic DNA or from cDNA. These clones genes included a number of genes for specific antigens and some have been used for the synthesis of antigens leading to the preparation of vaccines.

3. Synthetic peptides as vaccines: vaccines can also be prepared through short synthetic peptide chains.

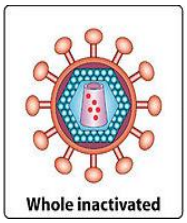
Types of vaccines

All available vaccines can be divided into two main categories:

- **living**: it uses live-attenuated organisms and they contain modified strains of a pathogen (bacteria or viruses) that have been weakened but are able to multiply within the body. These vaccines are able to induce a strong immune response, however, there is a possibility they can revert to the virulent form at any time.



- **non-living vaccines:** they are based on whole killed pathogens or components of them (subunit vaccines) as a capsule, partially purified toxins or polysaccharides. These vaccines are very efficacious and allowed the control and, in some cases, the eradication of very important infectious diseases such as smallpox and polio, at least in industrialized countries.



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Reverse vaccinology

Reverse vaccinology is an innovative technique for the development of new vaccines through the sequencing of the genome of the pathogen.
This technique consists in:

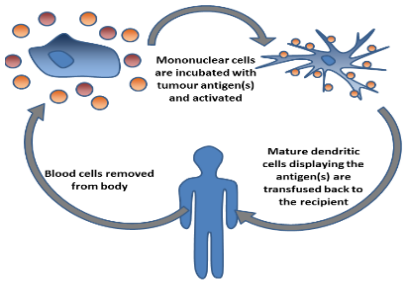
1. extracting entire bacteria genomes of chosen antigen and, thanks to the computer algorithms, we are able to locate a number of antigens more than the traditional approach;
2. Identifying the antigens.
3. On the basis of the DNA sequences, it is started the study on the biological role of each protein looking for those that could be used in the vaccine and which are easily recognized by the immune system.
4. This process leads to the identification of a few hundreds of interesting genes. Later these genes are rapidly cloned in order to produce the proteins they encode.
5. Proteins are evaluated for their ability to cause an immune response.
6. Isolate a dozen of antigens to be subjected to further analysis.

Experimental

The availability of complete genome sequences in combination with novel advanced technologies, such as bioinformatics, microarrays and proteomics, have revolutionized the approach to vaccine development and provided a new impulse to microbial research.

These are a number of innovative vaccines in development and in use:

Dendritic cell vaccines– dendritic cell therapy is an immune therapy that harnesses the body's own immune system to fight cancer. The dendritic cell itself is an immune cell whose role is the recognition, processing and presentation of foreign antigens to the T-cells in the effector arm of the immune system. Although dendritic cells are potent cells, they are not usually present in an adequate quantity to allow for a potent immune response. Dendritic cell therapy thus involves the harvesting of blood cells (monocytes) from a patient and processing them in the laboratory to produce dendritic cells which are then given back to a patient in order to allow massive dendritic cell participation in optimally activating the immune system.



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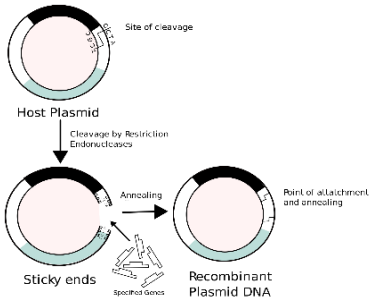
Recombinant Vector – they rely on the capacity of one or multiple defined antigens to induce immunity against the pathogen, when administered in the presence of adjuvants or when expressed by plasmids or harmless bacterial/viral vectors.

Several genes from different etiologic agents have been cloned, expressed and purified to be tested as vaccines. There are a variety of expression systems for antigenic protein components in which the DNA encoding the antigenic determinant can be inserted and expressed. However, several factors must be taken into account before selecting the system for antigen expression because they can interfere in the efficacy of production of recombinant antigens as vaccines.



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DNA vaccination – an alternative, experimental approach to vaccination called DNA vaccination, created from an infectious agent's DNA, is under development. The proposed mechanism is the insertion of viral or bacterial DNA into human or animal cells. Some cells of the immune system that recognize the proteins expressed will attack these proteins and cells expressing them. One potential advantage of DNA vaccines is that they are very easy to produce and store but DNA vaccination is still experimental and is not approved for human use.

Plants as bioreactors for vaccine production – Transgenic plants have been identified as promising expression systems for vaccine production. Complex plants such as tobacco, potato, tomato and banana can have genes inserted that cause them to produce vaccines usable for humans. Bananas have been developed in order to produce a human vaccine against Hepatitis B.

Biography

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