ISSN 2231-2218

ASIAN JOURNAL OF PHARMACEUTICAL AND BIOLOGICAL RESEARCH

AJPBR

Indexed by:

ROAD Crossref Universal Impact Factor IMPACT FACTOR SEARCH

Asian journal of Pharmaceutical and biological research 2231-2218
http://www.ajpbr.org/
Universal IMPACT factor 7
SJIF 2022: 4.465
Volume 12 Issue 3
SEP-DEC. 2023

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Application of bioengineering in medicine

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Abstract: In this article, the broad application of biotechnology is discussed in its essence, biotechnology biological systems, living organisms or their derivatives for specific practical reasons, biotechnology using living organisms or processes, robotic operations, medical virtual reality, biotechnology fields, molecular engineering of DNA and proteins, regenerative medicine, brief information on the creation of vaccines is given.

Keywords: biotechnology, fields of biotechnology, regenerative medicine, applied immunology, malignant tumors, chronic diseases, xenotransplantation, engineering viruses, creation of vaccines, nanobiotechnology.

Biotechnology (from Greek bíos – "life", tēncē – "art, skill, ability", lós – "word, meaning, thought, concept") - the possibilities of using living organisms, their systems or products the science of learning. Their vital activity in solving technological problems, as well as the possibility of creating living organisms with the necessary characteristics with the help of genetic engineering.

The widespread use of biotechnology often makes it difficult to define the subject in detail. Some definitions of biotechnology include:

"Biotechnology refers to any scientific application of biological systems, living organisms or their derivatives to produce/modify products or processes for specific practical reasons".

"The use of living organisms, systems or processes constitutes biotechnology."

As defined in the Collins English Dictionary, biotechnology is the use of living organisms, their parts or processes to develop active and useful products and services, such as waste treatment. The term covers processes ranging from using earthworms as a protein source to genetically modifying bacteria to produce human gene products such as growth hormones.

According to the Golden Treasury of Science and Technology, biotechnology is the science of using controlled life processes to mass produce valuable substances.

Biotechnology is often referred to as the application of genetic engineering in the 20th and 21st centuries, but the term also includes a broader set of processes for modifying biological organisms to meet human needs, beginning with artificial selection and the modification of plants and animals. means hybridization. Traditional biotechnological production using modern methods has the potential to improve the quality of food products and increase the productivity of living organisms.

Before 1971, the term "Biotechnology" was used mainly in the food and agricultural industry. Since the 1970s, scientists have used the term to refer to laboratory techniques such as the use of recombinant DNA and cell cultures grown in vitro.

Biotechnology is based on genetics, molecular biology, biochemistry, embryology, microbiology and cell biology, as well as applied sciences - chemical and information technology and robotics.

Medical biotechnology is a promising direction related to the development of new methods of treatment and diagnostics at the level of cells and tissues. In the material, we will tell you what tasks experts solve and what solutions will help bring the future closer.

Biotechnology is a multidisciplinary field in which cells and cell-derived molecules are used for various purposes1.

Biotechnology is divided into several areas. Experts conditionally assign their own color to each. Red color corresponds to medicine. Within this direction, modern treatment and diagnostic methods aimed at improving human life are being developed.

- vaccines;
- antibodies;
- therapeutic proteins;
- antibiotics;
- preparations based on stem cells;
- gene therapy;
- nanodevices.

Biotechnological developments are in demand in cancer treatment, immunotherapy, combating antibiotic resistance of microbes, tissue regeneration and other important areas.

The introduction of artificial intelligence into the healthcare sector through bioengineering has opened up a new wave of opportunities in medicine.

From diagnostic accuracy to surgical precision, patient care benefits, experts say. Here are just a few ways bioengineering will revolutionize healthcare in the future.

Robotic Operations: Artificial intelligence-powered robots for surgical procedures will lead to more minimally invasive surgeries, clearer incisions, less infection, better tissue recovery, and shorter hospital stays (Figure 1.).

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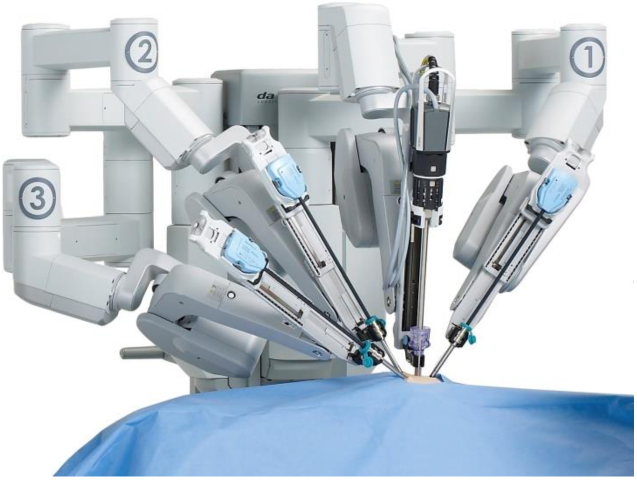

Figure 1. Robotic Operations.

Tissue engineering: Bioengineers are working to develop tissue and organ grafts that can be successfully transplanted into a human host. Using bio-ink technology, scientists create active cellular tissue that can be printed in thin layers by adding whole body parts (Figure 2.).

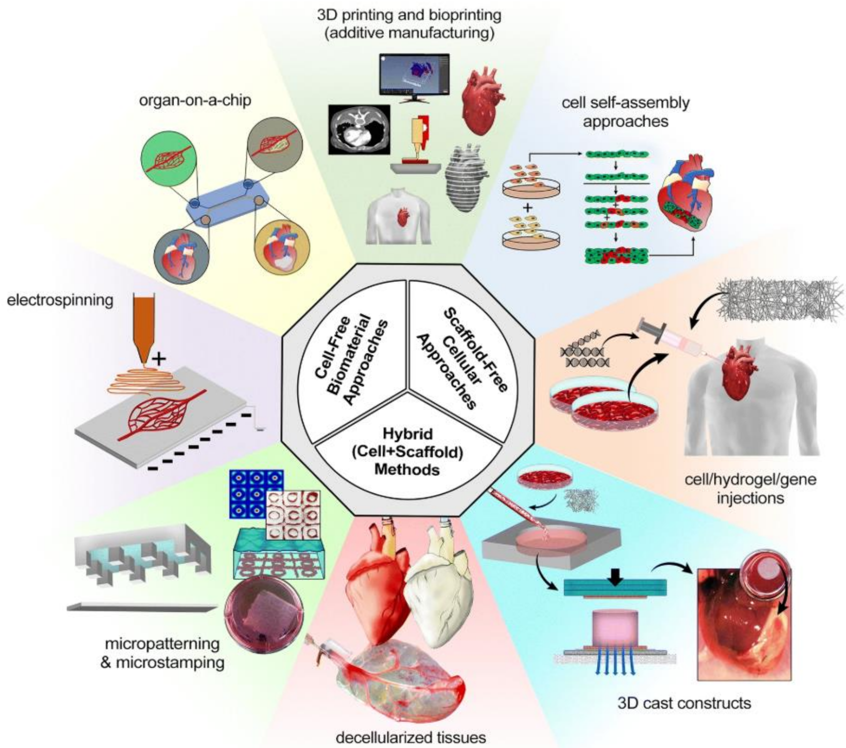

Figure 2. Tissue engineering.

Medical virtual reality: In virtual medical reality, doctors can visualize the entire anatomy of a patient and simulate operations before actual operations (Figure 3.).

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Figure 3. Medical virtual reality

Molecular engineering of DNA and proteins.

Genomic engineering is the study and modification of DNA sequences. Genome engineering techniques include editing the genome or sets of genes and editing individual genes.

Biotechnologists are developing gene editing systems:

• CRISPR-Cas. A system that performs immune function in microorganisms. This prevents them from being infected by viruses or phages that carry their own genetic material. The active element of the system is the Cas protein, which is capable of cleaving foreign DNA and protecting the host.

• ZNF. Zinc finger nuclease consists of two components. The first are synthetic proteins that have a zinc ion attached to a specific short section of DNA. The second is a nuclease, an enzyme that can break down DNA. Together, they work like genomic scissors, cleaving nucleotide sequences.

• TALEN. TALE is a protein from the plant bacteria Xanthomonas. A TALE recognizes a specific piece of DNA, and then a nuclease “cuts” it.

CRISPR-CAS, ZNF and TALEN are used in medicine to model human diseases in animals and cells. Molecular diagnosis and treatment of genetic and oncological diseases are carried out with the help of gene editing systems.

Regenerative medicine. Regenerative medicine deals with the development of solutions to replace lost tissues and organs or accelerate their healing.

"Red" biotechnology uses stem cells and turns them into other cells with a special function - nerve or heart, liver or blood. Stem cells come from embryos and adult tissues such as bone marrow or fat. Normal adult cells can be reprogrammed into stem cells.

One of the methods of tissue regeneration is bioprinting. Stem cells are implanted in natural or synthetic material. 3D printing equipment is used to create three-dimensional fabric. The printed tissue stimulates the formation of blood vessels and nerves by adding growth factors and progenitor cells.

Transplantation of bioprinting products is aimed at speeding up healing in cases of significant tissue loss, such as severe bone damage. Cartilage has a limited ability to repair itself, so the printed version can effectively replace the damaged material. Research is being conducted in the field of printing skin, nervous tissue, and liver cells.

Applied immunology. Antibodies are proteins produced by the body in response to the immune system. An antibody protects against a foreign substance - an antigen that can be microorganisms or chemicals.

Monoclonal antibodies are studied in "red" biotechnology - biomolecules that can recognize a specific site of an antigen. The "mother" of monoclonal antibodies is called a hybridoma. This is a cell line that is obtained by combining B lymphocytes, the immune cells that produce antibodies, and myeloma tumor cells.

Monoclonal antibodies are used in medicine to treat many pathologies.

• malignant tumors: melanoma, metastatic breast cancer, leukemia, colon cancer;

• chronic diseases: rheumatoid arthritis, osteoporosis, psoriasis;

• prevention of organ rejection after transplantation.

Cell therapy is a biotechnology-based therapeutic approach that uses living cells.

• The injected cell is capable of interacting with other cells and tissues of the body and responding to chemical, physical and biological stimuli.

• Stem cells and T cells are often used as cell therapies.

• Approved products are used for treatment of malignant blood diseases and immunodeficiency, tissue regeneration.

Xenotransplantation is the transplantation of cells, tissues and organs from a non-human donor. The development of the technology is due to the lack of human donors who can provide organs for transplantation. Human materials are often not available to treat certain diseases.

Early studies used primates as donors. Since the 1990s, pigs have taken their place. They grow quickly and their anatomy and physiology are similar to humans. The heart, kidneys, and liver are potential organs for xenotransplantation.

One of the problems with xenotransplantation is the human immune response to pig antigens. To reduce the risk of rejection, animals' organs are genetically modified to reduce the activity of antigens. The use of immunosuppressive therapy helps suppress the activity of immune cells.

Creation of vaccines. Biotechnology is developing modern types of vaccines.

1. A collection of organisms. The material used for a vaccine is usually a bacterium that lives in the body or a microorganism that causes a mild infection. They are genetically modified so that the immune system sees them as a stronger enemy than they actually are.

2. Engineering viruses. New fragments are added to the DNA of the virus. The modified virus causes the formation of a number of foreign proteins. Thus, you can protect against several infectious diseases at the same time.

3. DNA vaccines. DNA fragments encoding foreign proteins are selected. Added to these are protein sequences that enhance the immune response. Materials

are combined and processed. Plasmid is taken, it enters the body together with the vaccine. The plasmid is introduced into the host cell. The latter synthesizes foreign proteins, which causes an immune response.

Adjuvant vaccines consist of two components.

• antigen - a foreign protein or polysaccharide to which the immune system reacts;

• adjuvant - a substance that enhances the immune response.

Adjuvants have helped develop vaccines against the human papilloma virus (HPV), which increases the risk of developing certain types of cancer. Approved vaccines use aluminum hydroxide or aluminum hydroxyphosphate as adjuvants.

Nanobiotechnology. Nanobiotechnology works at the molecular and cellular level. The use of nanoparticles has great potential in the following areas.

• Cancer treatment. Nanoparticles have the ability to deliver and distribute drugs to the tumor site. Special molecules or monoclonal antibodies are added to the surface of nanoparticles to improve tumor detection.

• Tissue engineering and regenerative medicine. Biological materials, including nanoparticles, nanotubes, and nanofibers, are suitable tools for cell growth and development.

• Identification of biomolecules. Nanoparticles can detect viruses, hormones, antigens and DNA.

• Antimicrobial activity. Nanomaterials containing metal ions such as silver can suppress the activity of bacteria resistant to conventional therapy.

Nanoparticles can be smaller than one micrometer and can have different shapes - tubes, spheres or crystals.

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