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NANOROBOTS IN MEDICINE

Аннотация. Данная статья посвящена нанороботам, которые используются в медицине. В статье представлена информация о наномедицине и нанороботах в целом, основные аспекты создания роботов и ныне существующие прототипы. Основная цель статьи это собрать информация в целом о нанороботах и обозначить особенности прототипов.

Ключевые слова: Наномедицина, нанороботы, биотехнологии, прототипы нанороботов.

Abstract. This article is devoted to nanorobots, which are used in medicine. The article presents information on nanomedicine and nanorobots in general, the main aspects of creating robots and now existing prototypes. The main purpose of the article is to collect information on nanorobots as a whole and to identify the features of prototypes.

Key words: Nanomedicine, nanorobots, biotechnologies, prototypes of nanorobots.

Imagine that you are ill with a cold and go to the doctor for treatment, but instead of writing you a pill or shot, he sends you to a medical center that will "run" into your blood of tiny robots. They will find out the cause of the disease, go to the right system of organs and deliver the medicine. You will be surprised, but modern medicine is not so far from such devices that are already beginning to be used. These devices are called nanobots, which are created on the basis of nanoelectronic structures and

biotechnologies and acquire new properties that differ from the constituent molecules and atoms.

Nanomedicine - what is it?

According to the definition of Robert Freitas: " Nanomedicine is the tracking, correction, design and control of human biological systems at the molecular level using the developed nanoparticles and nanodevices" The emergence of nanomedicine is associated with 1957, when Richard Feynman pointed out to the world community that, in spite of fundamental knowledge about the microcosm, mankind does not know how to use all its possibilities for productive work in this industry.

"Molecular machines"

One of the founders of nanotechnology Eric Drexler described a new medical technology - nanomachines for repairing cells. In his opinion, medical nanorobots should be able to diagnose diseases, deliver medicines, circulate in human lymphatic and blood vessels and even perform surgical operations.

Inventions that make it possible to create nanorobots

In 2016 three scientists who contributed to nanotechnology received the Nobel Prize in Chemistry. In 1983, Jean Pierre Savage made the first development in nanotechnology. He was able to connect two ring-shaped molecules in a chain - such a connection is called a catenane. The molecules are linked together by a lighter mechanical bond, so they move freely. The approach based on catenanes made it possible to develop such complex topological structures as the triple catenanes, the trilulous knot and the Solomon knot.

In 1991 James Fraser Stoddart synthesized rotaxane, a compound consisting of a dumbbell-shaped molecule and a cyclic molecule, "put on" it. He "wound" the molecular ring on a thin molecular axis and showed that the ring is capable of moving along the axis. Then, by Stoddart himself and his assistants, a molecular "elevator" model was developed, again based on rotoxane. It allows you to control the motion of the matrix between two unique "floors", which are at a distance of only 0.7 nm from each other.

Bernard Ferring is the first person who could invent a molecular engine. In 1999, he developed molecular rotor blades, which constantly rotate in the same direction. On its basis, the so-called "nanocar" (nanocar) was obtained. The nano-car consists of four motor components, which work in pairs, rotating in different directions and thereby ensuring the movement of the machine over the metal surface.

How to create a "designer" of atoms and molecules?

Until now, there is no method of engineering design of molecular structures in the form of workable tiny robots. But 500-nm diameter motors have already been created, which can be used as engines for nanorobots, nanofluid and nanoelectronic "laboratory-on-chip" systems, software for modeling the behavior of nanorobots in the human body. There is a practical research program, founded by Robert Freitas and Ralph Merckle in 2000, and is aimed at creating a diamond factory that will create nanorobots based on diamond compounds. But bioengineers plan to create nanorobots from cellular organelles.

There are three main points on which scientists should concentrate: navigation, feeding and movement. Nanotechnology is considering various options for each of these aspects.

1. Navigation

One such method is the use of ultrasonic signals to locate the location of a nanorobot and direct it to its destination. Physicians would send ultrasound signals to the patient's body and record them, working on special equipment with ultrasound sensors. Using magnetic resonance imaging (MRI), doctors could locate the nanorobot and track it along the magnetic field.

2. Feeding of nanorobots

As the main sources of energy is expected to use their own reserves directly from the human bloodstream. Nanorobot with installed electrodes can form a "battery" based on electrolytes found in the blood. Another option is to create chemical reactions with blood to convert it into energy.

3. Movement of nanorobots.

Currently, two types of nano engine have been developed. One is a dielectrophoresis nanomotor. Another nanoengine has a shape of a spiral, which is a twisted quartz and nickel thread. It was found by the Israeli and German teams. In this case, control is due to an alternating magnetic field that completely excludes any kind of irradiation of the human body.

Prototypes of nanorobots

1. DNA nanorobots

In 2014, researchers from Bar-Ilan University in Israel demonstrated the possibility of creating several nanorobots based on DNA strands, which were then introduced into the body of laboratory cockroaches.

These DNA nanobots were folded DNA molecules, which, once trapped in a living organism, began to unfold and interact with each other and with the cells of that organism. Researchers "unwound" the strands of DNA, and then "tied" them into a new structure, similar to the "origami box". It was then placed on one chemical molecule

When colliding with certain proteins, the DNA-box opened and released chemical particles in the bends of DNA. During the experiment, DNA nanorobots showed high accuracy of functioning and interaction among themselves, bordering on the accuracy of the computer program.

2. Nanorobot – scallop

Scientists from the Max Planck Institute of Intelligent Systems in 2014 designed an unusual microscopic robot similar to a scallop for movement on the fluids of the human body. Similarly to this mollusk, the nanorobot is able to move due to movements of the shell flaps with the help of jet thrust. In this case, the robot has enough external electromagnetic field energy, which made it possible to dispense with a power source and reduce the dimensions of the shell

3. "Zinc Nano-Rockets"

Researchers from the University of California, San Diego, in 2015, created nanorobots whose micromotor is of a chemical nature and promotes nanobots due to

gas bubbles released during the reaction between the fluid inside the body and the material in the engine. Experimental living organisms were rodents.

The nanites, made from a special polymer, had the shape of a tube about 20 micrometers long and 5 micrometers in diameter and were covered with a thick layer of zinc. Nanorobots were introduced into the digestive tract of the animal and reached its stomach, where zinc began to react with hydrochloric acid, which is part of the digestive juices.

The liberated hydrogen escaped from the inner cavity of the nanobot tubes, turning them into a kind of miniature rockets. They developed a speed of about 60 micrometres per second, were able to leave the stomach and become attached to the walls of the intestine, where nanoparticles were released from drugs.

According to the data obtained during the experiment, the nanobots remained attached to the walls of the intestine for 12 hours, even despite the ingestion of food to the experimental animals, which is evidence of their effectiveness.

4. "Sharp" nanite

One of the latest advances in nanorobotics is the creation by researchers from Drexel University of tiny robots capable of developing high speed in a liquid medium. Nanorobots are chains of tiny round particles. The magnetic field rotates the particles and the longer the chain, the more rapid it can develop. Robots were created with chains of three "beads" to a chain of 13 particles, which reached a speed of 17.85 microns per second.

The movement of nanobots was possible due to the use of an external magnetic field. The faster the rotation speed of the field, the faster the chains moved. At the same time, a high frequency led to deformation of the chains and facilitated their separation into smaller chains: from three or four particles. Scientists plan to use these devices in the future to deliver medicinal substances through the blood vessels.

It is expected that the achievements in nanorobotics will be used not earlier, in half a century, however, the latest discoveries inspire confidence that this will happen much earlier. Let's hope that in a couple of centuries a person will be able to use

nanorobots in surgical operations, in the treatment of various diseases and for the revitalization and "repair" of a person.

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