WYŻSZA SZKOŁA TECHNICZNA W KATOWICACH
Katowice School of Technology

# Information and technologies in the development of socio-economic systems

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**Series of monogrfaphs Faculty of Architecture, Civil Engineering and Applied Arts**

Katowice School of Technology

Monograph 6

Wydawnictwo Wyższej Szkoły Technicznej w Katowicach, 2016

Series of monographs Faculty of Architecture, Civil Engineering and Applied Arts Katowice School of Technology
Monograph · 6



**ISBN: 978-83-942093-4-6**

**Editorial compilation**
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## 4.1. Up-to-date capabilities of nanotechnologies in medicine: educational aspect

Nanotechnology is a key concept of the early XXI century, a symbol of a new third scientific and technological revolution. This is the "highest" technology on which major economies spend today billions of dollars. Scientists predict that nanotechnologies in the XXI century will revolutionize the matter manipulation in the same way that computers in the XX century revolutionized information manipulation. Their development opens up great prospects for the development of new materials, improvement of communication, development of biotechnology, microelectronics, energy and healthcare. Among the most probable scientific breakthroughs the experts mention a significant increase in computer performance, restoration of human organs with the use of the newly reconstituted tissue, production of new materials created directly from given atoms and molecules, as well as new discoveries in chemistry and physics. The development of nanotechnology will lead to revolutionary changes in computer science at the expense of transformation of both its technical facilities (computer and microprocessor technology) and the range of tasks.

Training for medical profession in medical universities should direct students at future technologies, including nanodimensional technologies. That is why the development of on topic review lectures and its inclusion in medical informatics course is an important task by our opinion.

At the present stage of human development *nanotechnology* is understood to be interdisciplinary field of fundamental and applied science and technology that studies theoretical grounds and practical methods of investigation, analysis and synthesis, as well as production methods and the use of products with a given atomic structure by means of controlled manipulation of individual atoms and molecules.

Nanomedicine – is a new interdisciplinary field of medical science is currently in the stage of formationin. Its methods only emerge from laboratories and most of them yet exists only in the form of projects. However, most experts believe that these methods will be fundamental in the XXI century. For example, the National Institutes of Health included nanomedicine the five priority areas for the development of medicine of the XXI century, and the US National Cancer Institute is going to apply the achievements of nanomedicine in the treatment of cancer. A number of foreign scientific centers have already demonstrated prototypes in the areas of diagnosis, treatment, prosthesis and implantation.

At present, there are three approaches to nanomedicine, through which it is supposed to carry out diagnosis and treatment at the cellular, sub-cellular and molecular levels. These include the "top down", "wet" nanotechnology and molecular nanotechnology.

The approach of "top down" is to further improve existing microdevices, in the first place – in their further miniaturization. Modern technologies allow to make microelectronic devices such as micromotors, accelerometers, gyroscopes, various microsensors, microvalves, micropumps, and the transmission gear smaller than a micron.

Currently, a number of scientists around the world working on developing microdevices that could operate inside the human body. Such devices may be permanently fixed in the tissues, moving passively or actively. In the latter case, they can "crawl" on the surface of the inner cavities of the human body, swim in the internal fluids, or even "perforate" currently moves in the tissues.

For example, modern apparatus for investigation of the gastrointestinal tract [1, 2] has a size of several millimeters, carries a miniature video camera and lighting system. These frames are sent out. Devices of this kind it would be wrong to attribute to the field of nanomedicine. However, opening wide prospects of further miniaturization and integration with nanosensors and onboard systems control and communications on the basis of molecular electronics and other nanotechnology.

Energy sources such systems is the utilization of substances that are contained in the internal environment of the organism. In the future, such devices can be equipped with manipulators and devices for autonomous locomotion. In this case, they will be able to penetrate to the desired location of the organism, to collect there a local diagnostic information, delivering medicines and, in an even more distant future, to carry out "nanosurgical operation" destruction of atherosclerotic plaques, the destruction of the cells with signs of malignant transformation, restoration of invalid nerve fibers, etc.

At present viruses are actively used for entering into a cell of new genetic material [2, 3]. The term may be used various robots – viruses capable of recognizing a specific cell type which are located in particular state. Depending on the specific situation such robot virus can kill the cell (for example, causative agent diseases), or to introduce it in the required DNA or RNA molecules – up to a complete replacement of damaged genetic material.

Cells in the human body can move purposefully, sometimes long distances, to destroy other cells or, alternatively, incorporated into damaged tissue in place of the dead. By artificial modifications may make the cells to destroy atherosclerotic plaques, regenerate damaged organs, limbs, etc. The cells may carry the label, allowing them to monitor the movement of the body, secrete substances into the environment, supporting diagnostic information.

In humans, there is a huge variety of enzymes, proteins and compounds that have diverse and highly selective activity. Some of them, together with nucleic acids, genetic ensure operation mechanism. For example, a DNA molecule of enzyme reparazy moving along the DNA double helix, corrects errors in the nucleotide sequence constituting the helix. Such errors inevitably occur due to temperature, of various chemicals, radiation etc. Molecule DNA reparazy is a DNA molecule travels along it detects irregularities in the nucleotide sequence, decides which of the 2 strands of DNA assume correctly, "catches" from the environment desired nucleotide removes wrong and puts in its place the right. In practice, it behaves like a robot that solves a rather complex and multivariate problem situational behavior. Is a very promising direction is to modify the existing or the synthesis of new proteins, which in combination with a DNA capable of solving other more complex problems, such as the treatment of invalid or aged cells. It must be admitted, however, that the required level of understanding of the science of enzymes is not yet reached.

A simpler way would be to use the ability of the protein molecules and shorter polypeptides bind selectively to each other and with the molecules of other substances in preassigned supramolecular structure. In particular, in the preceding section was examined the ability of self-assembly of DNA molecules.

Molecular nanotechnology is the most promising approach to nanomedicine. It is based on the design and manufacture mechanosynthesis individual molecules having given properties in advance. An example of this is the construction of carbon – fullerenes and nanotubes, discussed above. According to the theory E. Drexler of the diamond-like carbon may also be produced molecules having a wide variety of form "parts" – gears, rods, components, bearings, joints, molecular turbine rotors, moving parts manipulators etc.

Currently, these molecules are synthesized, but calculations show that they may exist, and be resistant to interact with each other. It is expected that with the help of scanning probe microscopes, either by self-assembly molecule – "details" can be collected in an efficient nanoconstructions. Hypothetical nanoconstructions able to move in the environment and equipped with on-board control system are called nanobots.

Among the projects of future medical nanorobots already exists on the internal classification of the field of use in microbivores, respirocytes, klottotsity, vasculoid and others [2,4]. Microbivores belong to a class of medical nanorobots are artificial immune cells. They are designed to destroy pathogenic microorganisms in blood and ensure the transport of oxygen and carbon dioxide It is assumed that microbivores will be found in humans foreign elements and process them faster and neutral compounds "cleaner" than own phagocytes. Respirocytes erythrocytes are analogues that are considerably more functionality than their natural prototypes. Their implementation will reduce the constant human need for oxygen, allowing for a long time to go without him, that will help people, who suffer asthmatic conditions. It is assumed that these nanomachines will analyze the signals from the sensors to their adoption of the acoustic command from a doctor. Klottotsity artificial analogues of platelets. These machines will quickly arrest the bleeding by rapid delivery to the site of bleeding artificial connecting network, which allows to hold blood cells, stopping the flow of blood. Vasculoid – mechanical prosthesis that is based on microbivores, respirocytes and klottotsitov, which is part of a project to create a robotic blood ("Roboblood"). The machine is a set of medical nanobots able to live and function in the human body, performing all the functions of the natural circulatory system. It is assumed that the blood robototizirovannaya allow its owner to get rid of germs, viruses, atherosclerotic plaques, and repair damaged cells.

It is very relevant for nanomedicine is to create devices such as nanomanipulators. At present, prototypes of several options "nanotweezers" [4,5]. In one case, the carbon nanotubes used were two 50 nm in diameter, arranged in parallel on the sides of the glass fiber with a diameter of about 2 microns. When applying voltage to them nanotubes could diverge and converge like the halves of a pair of tweezers. In another case, we used a DNA molecule changes its geometry during the conformational transition or break bonds between the nucleotide bases in the parallel branches of the molecule.

There is a number of active nanomedicine technologies in the world have been developed for now. Selective drug delivery, quantum dots diagnostics, lab-on-a-chip, are referred to them. [4].

Selective drug delivery enables receiving of medicine by diseased organs without affecting sound tissues. Radiation therapy or chemotherapy, for example, kill malignant cells but in the same time they destroy normal tissues. Solution of this task becomes possible with creation of drug delivery vehicle. It allows to prolong activity of pharmaceutical substance, to provide necessary biocompatibility, to protect drugs from anticipatory biodegradation, to increase the ability of drugs to overcome membrane and hematoencephalitic barrier. Drug delivery vehicle also provides controlled release of pharmaceutical substance reducing side effects [6].

Application of transport allows to prolong the action of the drug compound and provide the necessary biocompatibility; protect drug compound from premature biodegradation; to increase its ability to overcome the blood-brain membranes and biological barriers; aiming to carry out a tissue and / or target-specific transport of the drug; to provide controlled release of drug compound to maintain its optimal therapeutic concentrations in blood and tissues while minimizing side effects.

List of nanometer structures that have already been applied or to be applied in the near future for the development of transport systems of drugs is large enough. These include fullerenes, dendrimers, lipochastitsy, nanoparticles of gold, silver, quantum dots, magnetic nanoparticles nanoparamagnetiki, nanocrystals and nanopowders, nanoparticles based on silicon, etc. In the last years, particular attention is paid to the phospholipid nanoparticles – colloidal transporters of drugs, the effectiveness of which make a substantial contribution sizes (less than 100 nm). Phospholipid nanoparticles (liposomes, micelles) Biodegradable, biologically inert, do not cause allergic, antigenic or pyrogenic reactions.

The surface lipid nanoparticles, as compared to other particles, can be easily modified for targeted delivery. They can be used to transport a very wide range of biologically active substances from medicinal substances to gene constructs. Today developed liposomal formulations of anticancer drugs (doxorubicin, methotrexate, vinblastine, actinomycin, L-asparaginase), and a number of peptides, bovine insulin, and anti-inflammatory corticosteroids (cortisone, hydrocortisone, dexamethasone). It looks very promising use of liposomal formulations for the treatment of intracellular parasitism (leishmaniasis, malaria, toxoplasmosis). It is an actual problem of encapsulation in the liposomes and intracellular introduction of nucleic acids.

For high-tech targeted drug delivery are also tiny self-assembling cube-shaped containers. They are relatively inexpensive, and can be produced in large numbers. Furthermore, due to its metal structure, the position of the containers inside the body can be monitored using magnetic resonance. It is believed that such microcontainers can be equipped with electronic components that will ensure their use as biosensors in the human body, or allow to release drugs in response to a radio signal from the outside.

Quantum dots (QD) are the new generation of biomarkers used for different fields of clinical diagnostics, such as cancer and autoimmune diseases [7]. QD are the fluorescent semiconducting nanocrystals possessing of new quantum properties due to its small size. Typical size of QD is lying in the range between 1 and 20 nm that depends on the nature of substance. QD absorbs electromagnetic radiation in the wide range of wavelengths and emits in the narrow wavelength region. It makes them effective source of light.

QD is the new generation of biomarkers used for different fields of clinical diagnostics, such as cancer and autoimmune diseases. QD may be traced inside the organism and biologically connected QD can help to detect viruses, bioplasts, cells, tissues.

Used in medicine lab-on-a-chip substitutes functions of variety traditional macroscopic laboratory processes, such as preliminary preparation, response, and detection [8]. Lab-on-a-chip (LOC) is a device used for biochemical and medical analysis. It is separate chip made of silicon or pyrex. Usually it is necessary to make a chemical reaction between reagent and biological material in order to detect or estimate quantitatively the specific substance in it. The substance which obtained as the result of chemical reaction can be revealed by analyzing device. If such substance has a color or beams, then spectrophotometry or fluorimetry can be used for its identification.

By the same principle, the LOC works with biological and non-biological material. Biological microchip has solid padding with small cells each one of them has fixed reagent served as probe for chemical reaction. Reagents can be mixed to required concentration or separated by transmitting of electrical impulses from microchip. Advantages of this technology is that the analysis is less time-consuming and needs just portable microdevice. Small amount of sample and reagent increases effectiveness and reduce the cost of microanalysis in analytical chemistry and biochemistry.

Special peculiarities of nanomaterials are used for growing of artificial organs and tissues. For example, the methods of cartilage regeneration cartilaginous tissue no donor cells of the patient [9, 10]. Special gel containing cartilage cells via the arthroscope is inserted through small incisions exterior. New tissue grows and is connected to the normal cartilage, and the gel self-destructs after a programmed period of time. Gel base comprise peptides capable of forming nanofibers 10-20 nanometers in diameter. The artificial nature of the nanoparticles eliminates the possibility of contamination of the patient.

In the field of dentistry developed direction of the use of nanomaterials for the restoration of the mechanical properties of dental enamel and surface technology by nanonapyleniya to make them antibacterial properties.

At the stage of testing is Self-retinal implant – a complex result of the application of microsystems technology and nanotechnology [11]. His task – to restore partial vision in cases of blindness caused by retinitis pigmentosa. The system includes a tiny camera in the frame of glasses that transmits images of the surroundings to a special adaptive signal processor. By wireless communication device transmits the image information inside of the diseased eye, where miniature electrodes deposited on the flexible film with the retina appropriately stimulate the optic nerve. If this development is successful, it will be the first man-machine interface for the view.

All of this is an incomplete list of nanotechnology in medicine.

It is impossible to ignore the opposite aspect of the impact of nanotechnology on the environment. Nanotechnology can benefit tremendously, but also cause great harm. They can pose a threat to the environment and human health. These nanotechnology products have a truly fantastic properties. They are ultra-strong, ultra-small and overactive. Risk of nanomaterials, primarily, consists in their microscopic size. Due to its small size, nanomaterials are chemically more active, but because of the large total surface area even nanosubstances low toxicity can be very toxic. In addition, the chemical properties of the "Nano-" can significantly vary due to manifestation of quantum effects, which ultimately can make a safe substance very dangerous. And finally, because of its small size nanoparticles freely pass through the cell membranes, damaging cellular organelles and disrupting the cells. Nanoworld man gives endless vistas, but also great risks, leading to a thorough examination of new technology solutions.

Thereby, given analysis of nanomedicine potentials in diagnostics, target-based treatment, detection of pathologic cells, high selective drags delivery by nanocontainers, allowed us to form the structure of review lectures for highly skilled health care manpower. The training of future doctors in the field of nanotechnologies lets us to support medical care system at more high level.

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## 4.2. Prediction of development of diabetes in patients with hypertension

The World Health Organization (WHO) and the United Nations (UN) identified diabetes as the most dangerous challenge to the world community in the XXI century. Over the past 20 years the number of diabetics has increased by 3 times, ahead of the spread of all communicable diseases [1]. In 2013, 382 million people worldwide suffer from diabetes, and by 2035 their number is expected to rise to 592 million [2].

High blood pressure is almost two times more common in people with diabetes than in those without. [3]. Compared with the general population in the European population mortality from cardiovascular disease in diabetic patients is increased more than 2-fold in men and more than 4-fold in women [4].

The frequency of arterial hypertension among diabetics koIt fluctuates from 20 to 60%, depending on use Bathrooms criteria for high blood pressuretion and the type of diabetes. Arterial hypertension has a significant impact on life nenny prognosis of patients with diabetes, significantly enforcement increased risk of cardiovascular and renal complications, which

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