ДОНСКОЙ ГОСУДАРСТВЕННЫЙ ТЕХНИЧЕСКИЙ УНИВЕРСИТЕТ

УПРАВЛЕНИЕ ДИСТАНЦИОННОГО ОБУЧЕНИЯ И ПОВЫШЕНИЯ КВАЛИФИКАЦИИ

Кафедра «Научно-технический перевод и профессиональная коммуникация »

# УЧЕБНОЕ ПОСОБИЕ

по английскому языку для студентов технических вузов

# «Нанотехнологии и наноматериалы»

Автор
Воронкина М.А.

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## Аннотация

Учебное пособие предназначено для студентов, обучающихся по специальности «Нанотехнология». Цель пособия – взаимосвязанное развитие навыков чтения и перевода текстов по специальности и различных видов речевой деятельности. Пособие способствует углублению языковых компетенций в сфере профессиональной коммуникации.

## Автор

Воронкина М.А., к.ф.н., доцент

# Оглавление

# MODULE 1

## Pre-reading

1. Check that you know the meaning of the following words. Use the dictionary where necessary.

| | | | | |
|---|---|---|---|---|
| matter | speculation | property | transparent | catalyst |
| device | extension | quantum | stable | fascination |
| length | recognition | dimension | liquid | manufacture |
| scale | entity | particle | insulator | disparate |
| field | significance | volume | conductor | overlap |

## Reading

2. Read the text.

### NANOTECHNOLOGY

Nanotechnology is a field of applied science and technology covering a broad range of topics. The main unifying theme is the control of matter on a scale smaller than 1 micrometer, normally between 1-100 nanometers, as well as the fabrication of devices on this same length scale. It is a highly multidisciplinary field, drawing from fields such as colloidal science, device physics, and supramolecular chemistry.

Much speculation exists as to what new science and technology might result from these lines of research. Some view nanotechnology as a marketing term that describes pre-existing lines of research applied to the sub-micron size scale.

Nanotechnology could variously be seen as an extension of existing science into the nanoscale, or as a recasting of existing sciences using a newer, more modern term. Two main approaches are used in nanotechnology: one is a "bottom-up" approach where materials and devices are built from molecular components which assemble themselves chemically using principles of molecular recognition; the other being a "top-down" approach where nano-objects are constructed from larger entities without atomic-level control.

The first distinguishing concepts in nanotechnology were made by physicist Richard Feynman at an American Physical Society meeting at Caltech in 1959. Feynman described a process by which the ability to manipulate individual atoms and molecules might be developed, using one set of precise tools to build and operate another proportionally smaller set, and so on down to the needed scale.

The term "nanotechnology" was defined by Tokyo Science University Professor Norio Taniguchi in a 1974 paper as follows: "Nanotechnology" mainly consists of the processing, separation, consolidation, and deformation, of materials by one atom or by one molecule". In the 1980s the basic idea of this definition was explored in much more depth by Dr. K. Eric Drexter, who promoted the technological significance of nanoscale phenomena.

Nanotechnology and nanoscience got started in the early 1980s with two major developments: the birth of cluster science and the invention of the scanning tunneling microscope (STM). This development let to the discovery of fullerenes in 1986 and carbon nanotubes a few years later. In another development, the synthesis and properties of semiconductor nanocrysals were studied. This led to a fast increasing number of metal oxide nanoparticles of quantum dots.

A unique aspect of nanotechnology is the vastly increased ratio of surface area to volume present in many nanoscale materials, which opens new possibilities in surface-based science, such as catalysis. A number of physical phenomena become noticeably pronounced as the size of the system decreases. These include statistical mechanical effects, as well as quantum mechanical effects, for example the "quantum size effect" where the electronic properties of solids are altered with great reductions in particle size. This effect does not come into play by going from macro to micro dimension.

However, it becomes dominant when the nanometer size range is reached. Additionally, a number of physical properties change when compared to macroscopic systems. One example is the increase in surface area to volume of materials. This catalytic activity also opens potential risks in their interaction with biomaterials.

Materials reduced to the nanoscale can suddenly show very different properties compared to what they exhibit on a macroscale, enabling unique applications. For instance, opaque substances become transparent (copper); inert materials become catalysts (platinum); stable materials turn combustible (aluminum); solids turn into liquids at room temperature (gold); insulators become conductors (silicon). A material such as gold, which is chemically inert at normal scales, can serve as a potent chemical catalyst at nanoscales.

Much of the fascination with nanotechnology stems from these unique quantum and surface phenomena that matter exhibits at the nanoscale. Molecular nanotechnology, sometimes called molecular manufacturing, is a term given to the concept of engineered nanosystems (nanoscale machines) operating on the molecular scale. It is especially associated with the concept of a molecular assembler, a machine that can produce a desired structure or device atom-by-atom using the principles of mechanosynthesis.

Manufacturing in the context of productive nanosystems is not related to, and should be clearly distinguished from, the conventional technologies used to manufacture nanomaterials such as carbon nanotubes and nanoparticles.

As nanotechnology is a very broad term, there are many disparate but sometimes overlapping subfields that could fall under its umbrella. Note that these are fairly nebulous and a single subfield may overlap many of them, especially as the field of nanotechnology continues to mature.

(From Шевцова Г.В., Москалец Л.Е. Английский язык для технических вузов: учебное пособие. М.: Наука, 2011).

**Vocabulary Practice and Grammar Revision**

3. Find the following in the text:

1. сфера прикладной науки
2. охватывающая широкий спектр тем
3. производство устройств
3. переработка существующих наук
4. шкала микронного размера
5. надмолекулярный
6. компоноваться химически
7. выдающиеся идеи
8. набор точных инструментов
9. технологическое значение
10. электронные свойства твёрдых тел
11. значительное сокращение размера частиц
12. этот эффект не действует
13. от макро- к микроизмерению
14. делая возможными уникальные применения

15. непрозрачные субстанции
16. непроводники становятся проводниками
17. молекулярное производство
18. довольно туманны
19. продолжает развиваться

4. Answer the following questions.

1. What does nanotechnology deal with?
2. What approaches are used in nanotechnology?
3. What concepts were made by Richard Feynman?
4. How the term "nanotechnology" was defined by Norio Taniguchi?
5. What development let to the discovery of fullerenes and carbon nanotubes?
6. What very different properties can materials show as they are reduced to the nanoscale?
7. What is the concept of a molecular assembler?

5. Translate into English:

1. Строительство материалов из молекулярных компонентов основано на принципах химического распознавания.
2. Материалы, уменьшенные до наноразмеров, демонстрируют совершенно новые свойства.
3. Твёрдые тела превращаются в жидкости при комнатной температуре.
4. Молекулярный конструктор производит желаемую структуру или устройство атом за атомом.
5. Один набор точных инструментов используется, чтобы построить другой, пропорционально меньший набор.
6. Наука о кластерах стала важным открытием для рождения нанотехнологии.

6. Revise degrees of comparison of adjectives and adverbs. Find in the text all the comparative forms of adjectives and adverbs. Write down the appropriate superlative forms. Complete your own sentences.

7. Form nouns using the following suffixes and translate them into Russian:

- ion (ation, cion) – accumulate, appreciate, assume, investigate, observe, suggest, predict, generalize, populate, interact, depredate, determine, classify, compose, found;
- ance (ence) – accept, exist, occur, depend, differ;
- ment – develop, measure, settle, require;
- ist – nature, ecology, speciality, pedology;
- ty – special, fertile, necessary, useable, peculiar.

8. Form the opposite of the following words by using the prefixes and translate them into Russian:

non – acid, resistant, renewable, sense, stop;
un – able, common, cultivated, explored, known, usual, healthy, necessary, important;
in – capable, efficient, human, exhaustable, essential, attentive, directly;
de – to compose, formation, to increase;
dis – advantage, order, integration, appearance.

9.Use the appropriate form of the participle and translate the sentences into Russian:

1. … the necessary data he continued his experiment. (obtaining, having obtained)
2. Nanotechnology is the field of applied science and technology specially … with the control of matter on a scale smaller than 1 micrometer. (concerned, concerning)
3. Nanotechnology is a multidisciplinary entity … various fields such as colloidal science, device physics, and supramolecular chemistry. (incorporating, incorporated)
4. This is a catalytic activity … potential risks in their interaction with biomaterials (opening, opened).
5. Materials … to the nanoscale can suddenly show very different properties. (reduced, reducing).
6. While … research he suggested a new theory. (doing, done)
7. The technology … improved the quality of the experiment. (applied, applying)
8. … a new method scientists obtained good results. (hav-

ing used, using)

**Language Development**

10. Discuss the various approaches in the definition of the term "nanotechnology".

11. Explain in English the meaning of the following words:

1. nanoscale
2. nano-object
3. nanomaterial
4. nanoparticle
5. nanosystems

12. Read the text again. Think of the most suitable headings for each paragraph of the text. Put down them. Make the writing plan of the text (use your headings).

13. Translate in writing paragraphs 10-12 from the text.

# MODULE 2

## Pre-reading

1. Consider and discuss the following questions.

1. What applications of nanotechnology do you know?
2. How long have people been using nanotechnology?
3. What can be the advantages and disadvantages applications of nanotechnology?

## Reading

2. Read the text.

### APPLICATIONS OF NANOTECHNOLOGY

Nanotechnology is the ability to manipulate individual atoms and molecules to produce nanostructured materials and submicron objects that have applications in the real world. Nanotechnology involves the production and application of physical, chemical and biological systems at scales ranging from individual atoms or molecules to about 100 nm, as well as the integration of the resulting nanostructures into larger systems.

People have been employing nanotechnology unwittingly for thousands of years. The processes of making steel, paintings and vulcanizing rubber rely on the properties of stochastically-formed atomic ensembles mere nanometers in size, and the distinguished from chemistry in that they don't rely on the properties of individual molecules. However, the development of modern applications in the field goes back to the 2000s. which are regarded as a new epoch in use of nanotechnology in commercial products. Nowadays the world around us is filled with applications that nanotechnology makes possible. Nanotechnology is influencing the development of a wide variety of very diverse fields; among these are electronics, biotechnology, and consumer applications. From tennis balls to bandages to palm pilots, nanotechnology is making a significant impact on the jobs we work at and the products that we employ.

One of the major applications of nanotechnology is in the area of nanoelectronics with the metal–oxide–semiconductor field-effect transistor (MOSFET). It's being made of small nanowires ~10 nm in length. Nanostructures provide this surface with superhydrophobicity, which lets water droplets roll down the inclined plane. There are a tremendous amount of other electronic applications out there that are effecting our everyday lives: faster and more powerful computers, palm pilots (blackberries), flash drives, digital cameras and displays, cell phones, LCDs, LEDs, MP3's, electronic ink displays, thin film batteries, and flexible electronics to name a few. All of these applications are possible and affordable due to the ability to work effectively and efficiently at the nano-scale.

Nanotechnology is already impacting the field of consumer goods, providing products with novel functions ranging from easy-to-clean to scratch-resistant. Modern textiles are wrinkle-resistant and stain-repellent; in the mid-term clothes will become "smart", through embedded "wearable electronics". In the clothing world, we have pants that repel water and won't stain shirts and shoe inserts that keep you cool in the summer and warm in the winter, and nano socks that don't "stink" due to the inclusion of nanotech materials (nanosized sliver particles). Nano-ceramic coatings are being utilized on photo quality picture paper to deliver sharper, higher quality "home-made" digital photo reproductions on your ink jet printer. Already in use are different nanoparticle improved products. Especially in the field of cosmetics, such novel products have a promising potential. Nanotechnology also has numerous potential applications in heavy industry.

An important subfield of nanotechnology related to energy is nanofabrication that is the process of designing and creating devices on the nanoscale. Creating devices smaller than 100 nanometers opens many doors for the development of new ways to capture, store, and transfer energy. Thus, researchers have now begun to utilize nanotechnology for battery technology.

Nanobiotechnology is the term that refer to the intersection of nanotechnology and biology. In this field nanotechnology uses biological systems as the inspirations for technologies not yet created. We can learn from eons of evolution that have resulted in elegant systems that are naturally created. Developing new tools for the medical and biological fields is another primary objective in nanotechnology. The imaging of native biomolecules, biological membranes, and tissues is also a major topic for the nanobiology researchers. Other topics concerning nanobiology include the use of cantilever array sensors and the application of nanophotonics for manipulating molecular processes in living cells. Recently, the use of microorganisms to synthesize functional nanoparticles has been of great interest. Microorganisms can change the oxidation state of metals. These microbial processes have opened up new opportunities for us to explore novel applications, for example, the biosynthesis of metal nanomaterials. This approach has become an attractive focus in current green bionanotechnology research towards sustainable development.

Nanomedicine as the field of medical application of nanotechnology ranges from the medical use of nanomaterials, to nanoelectronic biosensors, and even possible future applications of molecular nanotechnology. Current problems for nanomedicine involve regarding the issues related to toxity and enviromental of nanoscale materials. Respiration monitors utilizing nano-materials have been developed that are many times more sensitive than previous state of the art technology. Man-made skin is a nanofabricated network and is presently in use for skin graft applications. Some other nanotechnology applications which are currently under development in the biotech world are diabetic insulin biocapsules, pharmaceuticals utilizing "bucky ball" technology to selectively deliver drugs, and cancer therapies using targeted radioactive biocapsules.

Nanotechnology, like all new technologies, will have a profound effect on society. Public deliberations on risk perception in the US and UK carried out by the Center for Nanotechnology in Society found that participants were more positive about nanotechnologies for energy applications than for health applications. Health applications raise moral and ethical dilemmas such as cost and availability. There is significant debate about who is responsible for the regulation of nanotechnology. It is concluded that there is insufficient funding for human health and safety research, and as a result there is currently limited understanding of the human health and safety risks associated with nanotechnology. As a result, some academics have called for stricter application of the precautionary principle, with delayed marketing approval, enhanced labelling and additional safety data development requirements in relation to certain forms of nanotechnology.

(From 1.Springer Handbook of Nanotechnology / Bharat Bhushan (Ed.);
http://en.wikipedia.org/wiki/Applications_of_nanotechnology ;
http://www.nnin.org )

## Vocabulary Practice and Grammar Revision

3. Find the following in the text:

1. повышение требований
2. участники более благосклонно относятся
3. современные проблемы наномедицины
4. важные дебаты
5. рассмотрение вопросов, родственных
6. недостаточное финансирование
7. публичная дискуссия
8. ставят моральные и этические дилеммы
9. непосредственно финансируется
10. относится к смежной области
11. применяли нанотехнологии невольно
12. цена и доступность
13. наноструктуры обеспечивают эту поверхность
14. восприятие рисков
15. в отношении конкретных форм
16. глубокое воздействие
17. устойчивость к царапинам

Give definitions to the terms according to the text.

1. nanofabrication
2. nanomedicine
3. nanobiotechnology
4. superhydrophobicity

4. Answer the following questions

1. Are there any examples of the earlier applications of nanotechnology in the human history? What are they?
2. When did a new epoch in use of nanotechnology in commercial products begin?
3. What are the examples of modern application of nanotechnology?
4. What are the main subfields of nanotechnology?
5. What kind of application of achievements does take place in nanoelectronics (nanomedicine, nanobiotechnology, in the field of energy)?

6. How is nanotechnology impacting the field of consumer goods?
7. What are the main topics of public debates concerning the application of nanotechnology?

5. Translate the following phrasal verbs (two-part verbs):

to make up, to carry out, to account for, to bring about, to bring out, to deal with, to look for, to bear on, to give up, to keep to.

6. Revise the Present Perfect Continuous Tense. Change the following sentences into Present Perfect Continuous:

Model: *She is making an experiment in nanofabrication. – She has been making it for 2 hours (since 10 o'clock, since she came to the laboratory).*

1. We are discussing the findings.
2. She is studying at the library.
3. He is making calculations in the laboratory.
4. I am carrying out this research.
5. He is waiting for the results of his experiment.

7. Give answers to the following questions:

Model: *How long have you been doing research in nanotechnology?*
*I have been doing research for some years / since 2012.*

1. How long have people been employing nanotechnology?
2. Since when have modern applications in the field been developing?
3. How long have you been dealing with nanoelectronics?
4. How long have you been gathering the data for your research?
5. Since when have you been making your observations?

8. Ask questions:

Model: *Man for thousands of years has been changing the world.*
*How long has man been changing the world?*

1. He has been doing research in nanomedicine for 3 years.
2. We have been trying to solve this problem for nearly a year.
3. We have been gathering these data since last winter.
4. I have been writing this paper since Monday.
5. He has been investigating this problem since he joined the laboratory.

**Language Development**

Agree or disagree with the statements given below. Use the following phrases:

*That's right;*
*Exactly;*
*I am completely in favor for;*
*to it;*
*I am all for it;*
*I entirely agree with you.*

*I don't think so;*
*You are wrong there;*
*I am completely opposed*

1. More attention ought to be paid to nanotechnology.
2. Human priorities are not linked with ethics.
3. With application of nanotechnology man has violated laws of nature and is going to pay for it.
4. Application of nanotechnology does not affect human health and safety in any way.
5. Economic and technical progress is the more important field than ethical and moral matters.

9. Consider and discuss the matters.

1. Do you believe that technologies are able to find solutions to whatever problems are arisen? What is the basis of your opinion?
2. Do you agree that increase in funding is able to stop public deliberations on the moral and ethical matters of the application of new technologies?

10. Read the text again. Write out the key words of the text. Complete the plan of the text in writing. Present the information of the text schematically in 7-8 sentences according to your plan. Make use of the following phrases:

- The text under discussion reports on…
- The main objective (purpose, aim) of the text is…
- The text discusses/considers/analyses/deals with/emphasizes…
- Much attention is given to…

11. Translate in writing paragraphs 7, 8 from the text.

# MODULE 3

## Pre-reading

Think of as many words as possible related to the theme “environment”. What do you think about the links of nanotechnology and environment? What environmental impact of nanotechnology can you imagine? Try to guess the meaning of the term “green nanotechnology”? What can be its goals?

## Reading

1. Read the text.

### ENVIRONMENT AND NANOTECHNOLOGY

Science often faces with the problem of the balance of priorities. What are the benefits of a certain research for the technical progress? What conditions of the environment are best for people, for native vegetation and animals and for maintaining usability of the land? How do you balance costs, economic benefits and environmental impacts? How do you determine acceptable levels of risk?

Human priorities are linked strongly, on the one hand, with economic and political expediencies and, on the other hand, with ethics. All of the above questions are difficult and their relevance is obvious.

The environmental implications of nanotechnology are the possible effects that the use of nanotechnology and nanomaterials and devices can have on the environment. As nanotechnology is a new field there is a great deliberations regarding to what extent industrial and commercial use of nanotechnology will affect ecosystems and organisms.

The matter can be split into two aspects: the contribution to improvement of the environment (as a potential innovations), and the possibly novel type of pollution that application of nanotechnology might cause.

Nanopollution is a genetic name for all the waste generated by nanodevices or during the nanomaterials manufacturing process. This kind of wastes can float in the air and might easily penetrate into animal and plant cells causing unknown effects. Most human-made nanoparticles do not appear in nature, so living organisms may not have appropriate means to deal with nanowaste. This is probably one of the serious challenges nanotechnology deals with.

The term "green nanotechnology" is used to describe the development of clean technologies employing to minimize potential environmental and human health risks associated with the manufacture and use of nanotechnology products, and to encourage replacement of existing products with new nano-products that are more environmentally friendly throughout their lifecycle.

In addition to making nanomaterials and products with less impact to the environment, green nanotechnology also means using nanotechnology to make current manufacturing processes for non-nano materials and products more environmentally friendly. For example, nanoscale membranes can help separate desired chemical reaction products from waste materials. Nanoscale catalysts can make chemical reactions more efficient and less wasteful. Sensors at the nanoscale can form a part of process control systems, working with nano-enabled information systems. Using alternative energy systems, made possible by nanotechnology, is another way to "green" manufacturing processes.

The second goal of green nanotechnology involves developing products that benefit the environment either directly or indirectly. Nanomaterials or products directly can clean hazardous waste sites, desalinate water, treat pollutants, or sense and monitor environmental pollutants. Indirectly, lightweight nanocomposites for automobiles and other means of transportation could save fuel and reduce materials used for production; nanotechnology-enabled fuel cells and light-emitting diodes (LEDs) could reduce pollution from energy generation and help conserve fossil fuels; self-cleaning nanoscale surface coatings could reduce or eliminate many cleaning chemicals used in regular maintenance routines; and enhanced battery life could lead to less material use and less waste. Green Nanotechnology takes a broad systems view of nanomaterials and products, ensuring that unforeseen consequences are minimized and that impacts are anticipated throughout the full life cycle.

(From 1. Environmental Science, a global concern – Cuningham, Saudo – University of Minnesota, the USA. 2005;
http://en.wikipedia.org/wiki/Environmental_impact_of_nanotechnology
http://en.wikipedia.org/wiki/Green_nanotechnology )

**Vocabulary Practice and Grammar Revision**

2. Find the following in the text:

1. новый тип загрязнения
2. воздействие на окружающую среду
3. сталкиваться с проблемой
4. условия природной среды
5. экономические прибыли
6. предопределить приемлемые уровни
7. поддержание пригодности
8. прочно связаны
9. политическая целесообразность
10. уместность очевидна
11. вклад в улучшение среды
12. проникать  в клетки
13. подвергая неизвестному воздействию
14. подходящие средства
15. серьёзные вызовы
16. безопасные для окружающей среды
17. менее отходный
18. участки с опасными отходами
19. опреснять воду
20. экономить топливо

1. непредсказуемые последствия

Give definitions to the terms according to the text.

the environmental implications of nanotechnology
“green nanotechnology”
nanopollution
the balance of priorities

3. Answer the following questions according to the text.

1. What kind of questions does the science often face with?
2. What are human priorities linked strongly with?
3. What kind of deliberations is arisen concerning the environmental impact of nanotechnology?
4. What two aspects can this matter be split into?

5. What is the effect of nanopollution?
6. What is one of the most serious challenges nanotechnology deals with?
7. What are the goals of "green nanotechnology"

4. Give all possible variants and translate them into Russian:

precise (observation, measurements, values)
to consider ( a problem, data, the results)
to receive (a degree, a diploma, a medal, news, education, one's training, an award, a prize, a letter, a telegram)
to obtain (data, information, evidence, knowledge, a result)
to make (calculations, a conclusion, a contribution to, a discovery, an experiment, an investigation, measurements, a mistake, observations, a suggestion, a summary, analyses)
to do (experimental work, exercises, research in smth, theoretical studies on)
to gain (knowledge, recognition, experience)

5. Form adjectives by adding suffixes and translate them:

- al – environment, nation, biology, globe, region, policy;
- able – sustain;
- ful – meaning, beauty;
- ant (ent) – to depend, to ignore, to resist, to differ;
- ous – danger, advantage, nerve, fame;
- y – health, grass, water, wind, bush, ice, milk.

6. Explain the meaning of the following prefixes and translate the words into Russian:

mis – misunderstand, misprint, misspell;
pre – prehistorical, pre-establish, precursor, preface;
sub – subsoil, subtropical, subdivide;
uni – unicellular, uniform, unification.

Match English participles with Russian equivalents:

| | |
|---|---|
| a) released | 1. видоизменённый |
| b) reduced | 2. отобранный |
| c) selected | 3. применённый |
| d) developed | 4. произведённый |
| e) planted | 5. высвобожденный |
| f) cleaned | 6. поглощенный |
| g) absorbed | 7. посаженный |
| h) suggested | 8. очищенный |
| i) generated | 9. предложенный |
| j) applied | 10. развитый |
| k) modified | 11. сокращенный |

**Language Development**

Comment on one of the statements:

- Science often faces with the problem of the balance of priorities.
- Humans' technologies have impact on the environment and human priorities.

7. In pairs, discuss the possible effects of environmental implications of nanotechnology. Give examples for and against using nanotechnology from environmental point of view. Make use of the following linking words:

- *to start with/ first of all/ firstly*
- *secondly*
- *at first sight*
- *apparently*
- *the greatest advantage/ disadvantage*
- *however /yet*
- *what is more/ moreover*
- *on the one hand/ on the other hand*
- *in my opinion/ view*
- *personally I believe*
- *I feel strongly that*

- *I am concerned*
- *according to/ with reference to*
- *therefore/ thus/ as a result/ as a consequence*
- *in fact/ actually/ as a matter of fact*
- *finally*
- *to sum up*

8. Translate in writing paragraphs 5-8 from the text.

9. Write a short (in 100-120 words) composition discussing the matters of impact of nanotechnology on the environment in your own words.

# MODULE 4

## Pre-reading

1. Read the title of the text. What do you think the text is about? What do you think about the topicality of the microscopes for the field of nanotechnology? What kind of microscopes do you know? Which of them have you used in your studies?

## Reading

2. Read the text.

### SEEING NANOSTRUCTURES

Optical (light) Microscopes focus visible light through "lenses" to make a magnified image. They work essentially like a magnifying glass. However, even with the most precision, most sophisticated optical microscope, one problem remains – light waves are "big", at least on the scale of nanostructures. As the resolution power of these instruments is limited to about half of the wavelength of light, they can only reveal features down to ~250 nm.

When we talk about seeing small structures, it is important to distinguish between "resolution" and "magnification". We can "blow up" (magnify) an image (e.g. a picture) as much as we want – make it as big as a poster on your wall – but that does not make the image any sharper or increase our ability to resolve small structures – i.e. to have sharp edges and to distinguish separately closely spaced objects. Blowing up a picture too big just gives you a fuzzy big picture; that is called "empty magnification" and it does us little good. What is important is the ability to sharply see structures that are close to each other. This latter is called resolution and is the most important property of any microscope.

Optical microscopes give us a top-down, flat, "airplane" view of the surface. It is difficult to learn much about 3-D objects with a high powered optical microscope because they have very low "depth of field" – i.e. only objects at a certain, very narrow height will be in focus. For a high magnification optical microscope, this "depth of field" can be less than 1 micro meter – anything taller than 1 micrometer is out of focus and blurry.

With a super high quality optical microscope, we see and resolve structures down to about 250 nm. That still leaves a lot that we can't see. For those, we need an electron microscope!

Electron Microscopes use electron beams instead of visible light, enabling resolution of features down to a few nm. Several different types of EMs exist, including Scanning Electron Microscopy (SEM) and Transmission Electron Microscopy (TEM). Electron Microscopes use a beam of high energy electrons to probe the sample. Electrons do not suffer the same resolution limits that light does, so we can "see" features as small as 0.1 nm. This is the size of an individual atom. Electronic signal processing is used to create a picture of what the sample would look like if we could see it. While electron microscopy offers finer resolution of features than does optical microscopy, it requires vacuum conditions in order to maintain a focused electron beam. This makes electron microscopy inconvenient for examining many biological samples, which must first be preserved and coated with layers of metal atoms. Another advantage of electron microscopes is that they have both high magnification and high depth of field. We can see objects as in apparent three dimensions. This is again due to the short "wavelength" of electrons. You may have seen some really "monster" like pictures of bugs that highlight the imaging capabilities of the scanning electron microscope. High quality electron microscopes can cost from $250,000 to $1,000,000! They are one of the most useful instruments in our laboratories.

Scanning Probe Microscopes (SPM) of various types trace surface features by movement of a very fine pointed tip mounted on a flexible arm across a surface. SPM enables resolution of features down to ~1 nm in height, allowing imaging of single atoms under ideal conditions. Scanning Tunneling Microscopes (STM) measure current (i.e., electron flow) between the probe tip and sample, essentially acting like a tiny voltmeter. This method requires that the sample be electrically conductive. Atomic Force Microscopes (AFM - sometimes call Scanning Force Microscopes) measure interaction forces between probe tip and sample, providing information on the mechanical properties of surfaces. They can measure forces of 10-9 Newton. (For comparison, the force exerted by an apple is ~1 N.) AFMs are widely used to measure surface topography of many types of sample and do not require special conditions such as conductive surfaces or vacuum.

Scanned probe microscopes and particularly AFMs basically see things by touching. Imagine you have your right hand in a dark box with a mystery object and you are trying to figure out what the object is, without looking. One systematic way to do this would be to touch every point on a grid, say 30 points wide and 30 points deep, covering the entire floor of the box. Imagine that with your left hand, you record the "height" (or any other physical property) at each grid point on a piece of graph paper. You could then make a 3-d graph surface, or a 2-d plot with colors indicating height. After touching and recording 900 points, you would have a "picture" of the object. That is exactly what an atomic force microscope does, except the AFM uses a very fine point instead of a finger, and is built on a mechanism that can reproducibly move the tip less than 0.1 nm between points. Scanning probe microscopes can actually "feel" the bumps due to individual atoms and molecules!

Amazing Creatures with Nanoscale Features-Part 1 developed at Penn State's Center for Nanotechnology Education and Utilization.

This animation is an introduction to microscopy, scale, and applications of nanoscale properties. It introduces some of the tools that are used by scientists to visualize samples that are smaller than what we can see with our eyes. This includes the optical microscope, scanning electron microscope, and the atomic force microscope.

It has been 25 years since the scanning tunneling microscope (STM) was invented, followed four years later by the atomic force microscope, and that's when nanoscience and nanotechnology really started to take off. Various forms of scanning probe microscopes based on these discoveries are essential for many areas of today's research. Scanning probe techniques have become the workhorse of nanoscience and nanotechnology research.

(From "Seeing Nanostructures" by Ethan Allen, U. Washington Lynn Rathbun, Cornell
http://www.nnin.org/news-events/spotlights/seeing-nanostructures )

**Vocabulary Practice and Grammar Revision**

3. Translate into English:

1. Оптические микроскопы создают увеличенный образ, работая, по существу, подобно увеличительному стеклу.
2. Разрешительная мощность даже самых точных и сложных оптических микроскопов ограничена примерно половиной длины световой волны.
3. Мы можем «раздуть» образ, но это не сделает его

сколь-нибудь резче.

4. Оптические микроскопы дают плоский вид поверхности сверху.
5. Всё, что свыше одного микрометра – не в фокусе и расплывчато.
6. Электронные микроскопы используют пучки электронов вместо видимого света.
7. Электронный микроскоп требует условий вакуума, чтобы сфокусировать пучок электронов.
8. Эта анимация – введение в микроскопию, систему масштабов и применение свойств объектов наномасштабов.

4. Answer the questions:

1. What is the difference between "resolution" and "magnification"?
2. What are the possibilities and drawbacks of optical (light) microscopes?
3. What is the principle of work of electron microscopes (scanned probe microscopes)?
4. What is the significance of scanning probe techniques for nanoscience and nanotechnology research?
5. When did nanotechnology really start to take off?
6. Why have scanning probe techniques become the workhorse of nanoscience and nanotechnology research?

5. Insert the verbs: to do or to make; to receive or to obtain

1) I've got a lot of work …
2) He has got a lot of measurements …
3) I research in the field of nanotechnology.
4) He has … the award for the discovery … by him.
5) When did you … your degree?
6) He has succeeded in … some data of interest.
7) As far as I understood, you … your education at the University. Is it really so?
8) I hope the results … by you will help you to proceed with your work.
9) I've … some experiments and let me … a summary.

6. Explain the meaning of the following prefixes and translate the words into Russian:

re – restructure, recombine, renewable, recycle, recovery;
self – self-acting, self-consistent, self-recording, self-sufficient, self-control;
non – nondestructive, nonresistant, nonsense, nonacid;
in – inequitable, incapable, inefficient, inhuman, inessential, injustice, invisible, inorganic, insoluble;
out – outdo, output, outside, outstretched, outstanding;
de – to decrease, discoloration, to decompose to delay, deformation.

**Language Development**

7. Correct the wrong statements using the following as phrase openings:

- *On the country;*
- *I don't believe that;*
- *It is considered that;*
- *In my opinion;*
- *however according to the text;*
- *I don't think that;*
- *I'm afraid you are mistaken;*
- *Sorry I can't agree with you.*

1. Optical microscopes require vacuum conditions in order to maintain a focused electron beam.
2. The atomic force microscope was invented ten years later the scanning tunneling microscope was developed.
3. Electron Microscopes can give us only a top-down, flat, "airplane" view of the surface.
4. Optical microscopes use electron beams instead of visible light, enabling resolution of features down to a few nm.
5. Optical microscopes basically see things by touching.
6. Optical microscopes measure current between the probe tip and sample, essentially acting like a tiny voltmeter.
7. Optical microscopes can actually "feel" the bumps due to individual atoms and molecules.

8. Optical observations have become the workhorse of nanoscience and nanotechnology research.

8. Compare the possibilities of various types of microscope according to the text.

9. Summarize the text in 7-8 sentences. Make use of the following phrases:

*The text under discussion reports on…*
*The main objective (purpose, aim) of the text is…*
*The text discusses/considers/analyses/deals with/emphasizes…*
*Much attention is given to…*

10. Translate in writing paragraphs 7-10 from the text.

# MODULE 5

## Pre-reading

1. Find the odd word. Explain your choice.

1) nanowires, nanotubes, nanodevices, nanoparticles, monolayers;
2) nanometres, nanoparticles, nanomaterials, monolayers, engineered surfaces;
3) formed, made, shaped, produced, grown, observed, created.
4) large, tiny, small, useful, huge, big.

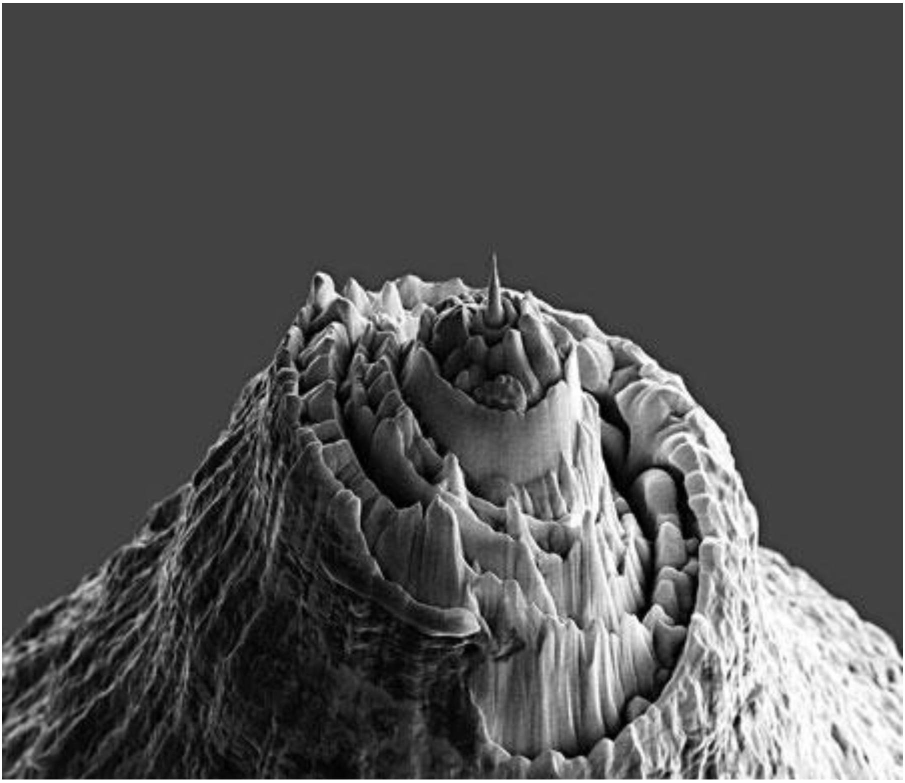
## Reading

2. Read the text.

### NEW MATERIALS: NANOMATERIALS

Many nanotechnologies are concerned with producing new or enhanced materials.

Current applications of nanoscale materials include very thin coatings used, for example, in electronics and active surfaces (for example, self-cleaning windows). In most applications the nanoscale components will be fixed or embedded but in some, such as those used in cosmetics and in some pilot environmental remediation applications, free nanoparticles are used.



*Gold Tip for SNOM, imaged by SEM, 2006, Gian Carlo Gazzadi and Pietro Gucciardi, with Lucia Covi.(www.s3.infm.it/blowup) From Blow Up. Images from the nanoworld, edited by S3 Research Center (INFM-CNR), Damiani, Bologna. © S3 National Research Center (INFM-CNR), Modena, Italy*

The ability to machine materials to very high precision and accuracy (better than 100nm) is leading to considerable benefits in a wide range of industrial sectors, for example in the production of components for the information and communication technology, automotive and aerospace industries. Nanomaterials are not simply another step in the miniaturization of materials. They often require very different production approaches.

One-dimensional nanomaterials, such as thin films and engineered surfaces, have been developed and used for decades in fields such as electronic device manufacture, chemistry and engineering. In the silicon integrated-circuit industry, for example, many devices rely on thin films for their operation, and control of film thicknesses approaching the atomic level is routine.

Monolayers (layers that are one atom or molecule deep) are also routinely made and used in chemistry. The formation and properties of these layers are reasonably well understood from the atomic level upwards, even in quite complex layers (such as lubricants). Advances are being made in the control of the composition and smoothness of surfaces, and the growth of films.

Engineered surfaces with tailored properties such as large surface area or specific reactivity are used routinely in a range of applications such as in fuel cells and catalysts. The large surface area provided by nanoparticles, together with their ability to self assemble on a support surface, could be of use in all of these applications.

Although they represent incremental developments, surfaces with enhanced properties should find applications throughout the chemicals and energy sectors. The benefits could surpass the obvious economic and resource savings achieved by higher activity and greater selectivity in reactors and separation processes, to enabling small-scale distributed processing (making chemicals as close as possible to the point of use). There is already a move in the chemical industry towards this. Another use could be the small-scale, on-site production of high value chemicals such as pharmaceuticals.

Two dimensional nanomaterials such as tubes and wires have generated considerable interest among the scientific community in recent years. In particular, their novel electrical and mechanical properties are the subject of intense research.

Carbon nanotubes were first observed by Sumio Iijima in 1991. Carbon nanotubes are extended tubes of rolled graphene sheets. There are two types of carbon nanotubes: single-walled (one tube) or multi-walled (several concentric tubes). Both of these are typically a few nanometres in diameter and several micrometres to centimeters long.

Carbon nanotubes have assumed an important role in the context of nanomaterials, because of their novel chemical and physical properties. They are mechanically very strong (their young's modulus is over 1 terapascal, making carbon nanotubes as stiff as diamond), flexible (about their axis), and can conduct electricity extremely well (the helicity of the graphene sheet determines whether the carbon nanotubes is a semiconductor or metallic). All of these remarkable properties give carbon nanotubes a range of potential applications: for example, in reinforced composites, sensors, nanoelectronics and display devices.

Carbon nanotubes are now available commercially in limited quantities. They can be grown by several techniques. However, the selective and uniform production of carbon nanotubes with specific dimensions and physical properties is yet to be achieved. The potential similarity in size and shape between carbon nanotubes and asbestos fibres has led to concerns about their safety.

Inorganic nanotubes and inorganic fullerene-like materials based on layered compounds such as molybdenum disulphide were discovered shortly after carbon nanotubes. They have excellent tribological (lubricating) properties, resistance to shockwave impact, catalytic reactivity, and high capacity for hydrogen and lithium storage, which suggest a range of promising applications. Oxide-based nanotubes (such as titanium dioxide) are being explored for their applications in catalysis, photo-catalysis and energy storage.

Nanowires are ultrafine wires or linear arrays of dots, formed by self-assembly. They can be made from a wide range of materials. Semiconductor nanowires made of silicon, gallium nitride and indium phosphide have demonstrated remarkable optical, electronic and magnetic characteristics (for example, silica nanowires can bend light around very tight corners).

Nanowires have potential applications in high-density data storage, either as magnetic read heads or as patterned storage media, and electronic and opto-electronic nanodevices, for metallic interconnects of quantum devices and nanodevices.

The preparation of these nanowires relies on sophisticated growth techniques, which include selfassembly processes, where atoms arrange themselves naturally on stepped surfaces, chemical vapour deposition onto patterned substrates, electroplating or molecular beam epitaxy. The 'molecular beams' are typically from thermally evaporated elemental sources.

The variability and site recognition of biopolymers, such as DNA molecules, offer a wide range of opportunities for the self-organization of wire nanostructures into much more complex patterns. The DNA backbones may then, for example, be coated in metal. They also offer opportunities to link nano- and biotechnology in, for example, biocompatible sensors and small, simple motors. Such self-assembly of organic backbone nanostructures is often controlled by weak interactions, such as hydrogen bonds, hydrophobic, or van der Waals interactions (generally in aqueous environments) and hence requires quite different synthesis strategies to carbon nanotubes, for example. The combination of one-dimensional nanostructures consisting of biopolymers and inorganic compounds opens up a number of scientific and technological opportunities.

(From http://www.nanowerk.com/nanotechnology/introduction/introduction_to_nanotechnology_2.php )

**Vocabulary Practice and Grammar Revision**

3. Answer the questions:

What kind of materials producing are nanotechnologies often concerned with?

What are the properties of coating current applications of nanoscale materials include used?

Where are engineered surfaces with tailored properties used?

What properties of two dimensional nanomaterials are the subject of intense recent research?

What are novel chemical and physical properties of carbon nanotubes?

What are potential applications of nanowires?

What does the preparation of nanowires rely on?

4. Find in the text the definition of:

a. monolayers
b. carbon nanotubes
c. nanowires

5. Give Russian equivalents for:

1. to be concerned with
2. enhanced materials
3. current applications
4. coating
5. embedded
6. high precision and accuracy
7. considerable benefits
8. electronic device manufacture
9. one-dimensional nanomaterials
10. layer

11. tailored properties
12. self assemble
13. incremental developments
14. the benefits could surpass
15. assumed an important role
16. potential similarity
17. sophisticated growth techniques
18. thermally evaporated elemental sources

6. Form adjectives from the following nouns by adding the suffix "al" and translate them into Russian:

function
origin
condition
environment
centre
structure
practice
nature
evolution
addition
logic
observation

7. Form Present and Past Participles from the following verbs and use them in the sentences of your own.

to cause
to follow
to result in
to develop
to grow
to destroy
to obtain
to reduce
to face
to affect
to increase

8.Match the English Passive constructions with the Russian equivalents:

| | |
|---|---|
| a) was published | 1. поглотятся |
| b) is being reduced | 2. были изобретены |
| c) will be selected | 3. очищаются |
| d) has been developed | 4. снижается |
| e) were invented | 5. был опубликован |
| f) are being cleaned | 6. был разработан |
| g) will be absorbed | 7. был предложен |
| h) was suggested | 8. будет отобран |

**Language Development**

9. Agree or disagree with the statements given below. The following phrases may be helpful.

*|Exactly.* *You are wrong there.*
*Quite the contrary.* *Quite the contrary.*
*That's right.* *I am afraid. I can't agree with you.*
*Not at all.* *I entirely agree with you.*
*Not quite.*

1. In most applications the nanoscale components will be free.
2. Nanowires are ultrafine wires or linear arrays of dots, formed by self-assembly.
3. Carbon nanotubes were first observed by Sumio Iijima in 1961.
4. Carbon nanotubes are now available commercially in unlimited quantities.
5. The combination of one-dimensional nanostructures consisting of biopolymers and inorganic compounds opens up a number of scientific and technological opportunities.
6. Carbon nanotubes have assumed an important role in the context of nanomaterials, because of their novel chemical and physical properties.
7. Monolayers have not used in chemistry yet.
8. Nanowires have potential applications in electronic and opto-electronic nanodevices.

10. Read the text again. Summarize the article in 7-8 sentences. Make use of the following phrases:

*It is reported that…*
*… is compared*
*… is analyzed in detail*
*The text under discussion reports on…*
*The main objective (purpose, aim) of the text is…*
*The text discusses/considers/analyses/deals with/emphasizes…*
*Much attention is given to…*

11. Prepare a report on the topic "Potential applications of nanomaterials".

12. Translate in writing paragraphs 13-16 from the text.

**Scanning reading**

13. Read the following text once without a dictionary. Try to catch the main ideas. Retell the text briefly in English.

**HOW BIG?**

Nanotechnology deals with the very smallest components of our world – atoms and molecules. Trying to understand just how small the nanoscale is can be very difficult for people.

A nanometer is a unit of measurement for length just as you have with meters and centimeters. A nanometer is one billionth of a meter, 0.000000001 or 10-9 meters. For comparison, a human hair is about 60-80,000 nanometers wide.

The word nano comes from the Greek word for "dwarf."

The term nanoscale is used to refer to objects with dimensions on the order of 1-100 nanometers (nm).

To understand how small a nanometer is, we typically compare the nanoscale to objects that we know how big or small they are. Here are some examples:

- a human hair is about 60,000 – 80,000 nm wide
- a fingernail grows 1 nm per second
- a DNA molecule is 2-3 nm in wide
- A 2 meter person is 6 feet 6 inches tall or 2 billion nanometers

Another way to help in the understanding of the minuteness of a nanometer is to examine objects on a size scale.

Scientists have discovered that materials at small dimension have small particles, thin films, etc- can have significantly different properties than the same materials at larger scale. There are thus endless possibilities for improved devices, structures, and materials if we can understand these differences, and learn how to control the assembly of small structures.

(From http://www.nnin.org/news-events/spotlights/how-big)

# MODULE 6

## Pre-reading

1. Read the title of the text. What do you think the text is about? What do you know on the topic?

## Reading

2.Read the text.

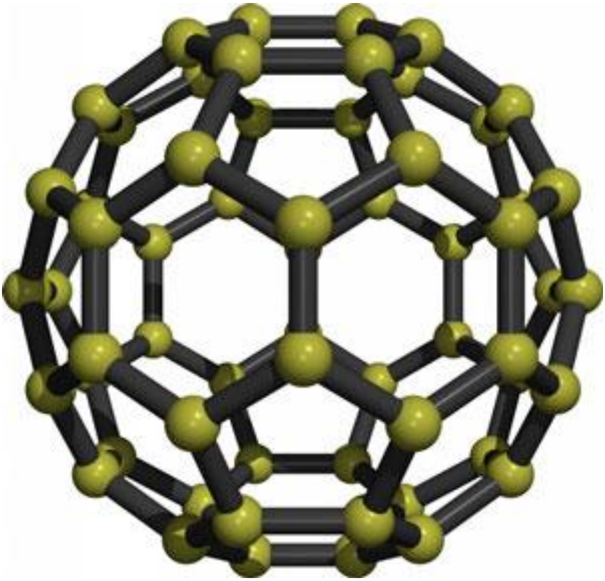
### NANOPARTICLES

Nanoparticles are often defined as particles of less than 100nm in diameter. We classify nanoparticles to be particles less than 100nm in diameter that exhibit new or enhanced size-dependent properties compared with larger particles of the same material. Nanoparticles exist widely in the natural world: for example as the products of photochemical and volcanic activity, and created by plants and algae. They have also been created for thousands of years as products of combustion and food cooking, and more recently from vehicle exhausts. Deliberately manufactured nanoparticles, such as metal oxides, are by comparison in the minority.

Nanoparticles are of interest because of the new properties (such as chemical reactivity and optical behaviour) that they exhibit compared with larger particles of the same materials. For example, titanium dioxide and zinc oxide become transparent at the nanoscale, however are able to absorb and reflect UV light, and have found application in sunscreens. Nanoparticles have a range of potential applications: in the short-term in new cosmetics, textiles and paints; in the longer term, in methods of targeted drug delivery to improve bioavailability of a drug. Bioavailability refers to presence of drug molecules where they are needed in the body. Nanoparticles can also be arranged into layers on surfaces, providing a large surface area and hence enhanced activity, relevant to a range of potential applications such as catalysts.

Manufactured nanoparticles are typically not products in their own right, but generally serve as raw materials, ingredients or additives in existing products. Nanoparticles are currently in a small number of consumer products such as cosmetics and their enhanced or novel properties may have implications for their toxicity. For most applications, nanoparticles will be fixed (for example, attached to a surface or within in a composite) although in others they will be free or suspended in fluid.

In the mid-1980s a new class of carbon material was discovered called carbon 60 (C60). Harry Kroto and Richard Smalley, the experimental chemists who discovered C60 named it "buckminsterfullerene", in recognition of the architect Buckminster Fuller, who was well-known for building geodesic domes, and the term fullerenes was then given to any closed carbon cage. C60 are spherical molecules about 1nm in diameter, comprising 60 carbon atoms arranged as 20 hexagons and 12 pentagons: the configuration of a football.



*Fullerenes (carbon 60)*

In 1990, a technique to produce larger quantities of C60 was developed by resistively heating graphite rods in a helium atmosphere. Several applications are envisaged for fullerenes, such as miniature 'ball bearings' to lubricate surfaces, drug delivery vehicles and in electronic circuits.

Dendrimers are spherical polymeric molecules, formed through a nanoscale hierarchical self-assembly process. There are many types of dendrimer; the smallest is several nanometres in size. Dendrimers are used in conventional applications such as coatings and inks, but they also have a range of interesting properties which could lead to useful applications. For example, dendrimers can act as nanoscale carrier molecules and as such could be used in drug delivery. Environmental clean-up could be assisted by dendrimers as they can trap metal ions, which could then be filtered out of water with ultra-filtration techniques.

Nanoparticles of semiconductors (quantum dots) were theorized in the 1970s and initially created in the early 1980s. If semiconductor particles are made small enough, quantum effects come into play, which limit the energies at which electrons and holes (the absence of an electron) can exist in the particles. As energy is related to wavelength (or colour), this means that the optical properties of the particle can be finely tuned depending on its size. Thus, particles can be made to emit or absorb specific wavelengths (colours) of light, merely by controlling their size. Recently, quantum dots have found applications in composites, solar cells (Gratzel cells) and fluorescent biological labels (for example to trace a biological molecule) which use both the small particle size and tuneable energy levels. Recent advances in chemistry have resulted in the preparation of monolayer-protected, high-quality, monodispersed, crystalline quantum dots as small as 2nm in diameter, which can be conveniently treated and processed as a typical chemical reagent.

(From http://www.nanowerk.com/nanotechnology/introduction/introduction_to_nanotechnology_10.php)

**Vocabulary Practice and Grammar Revision**

3.Give definitions to the terms according to the text.

dendrimers
nanoparticles
quantum dots

4.Give Russian equivalents for:

1) products of combustion
2) vehicle exhausts

3) algae
4) deliberately manufactured
5) reflect UV light
6) in the short-term
7) enhanced activity
8) lubricate surfaces
9) drug delivery vehicles
10) electronic circuits

5. Answer the questions:

1) Why are nanoparticles of interest?
2) What are potential applications of nanoparticles?
3) What was Buckminster Fuller known for?
4) What applications are envisaged for fullerenes?
5) Where are dendrimers (quantum dots) used?

6.Match English Modal verbs and their equivalents with Russian phrases:

| | |
|---|---|
| a) are able to carry out | 1. возможно, повлияет |
| b) have to develop | 2. должен начаться |
| c) must look for solution | 3. могло бы привести к |
| d) have to hurry | 4. в состоянии выполнить |
| e) may influence | 5. возможно, приведет к |
| f) could result in | 6. должны разрабатывать |
| g) is to begin | 7. вынуждены поторопиться |
| h) might lead to | 8. должны искать решение |

7.Translate the following sentences into Russian. Pay attention to the modal verbs:

1) You have to make use of these facts to prove your theory.
2) One must be sure that the increasing nanopollution is a serious problem today.
3) My fellow student is to make part in the scientific conference on the problems of nanotechnology.
4) These different aspects of the theory must be taken into account.
5) The engineers should study the problem of using nanomaterials.
6) The scientists have to develop new approaches in the field.
7) One should remember that science is a creative and dy-

namic activity.
8) We are to take care of the ethical and moral matters.
9) One may watch more and more young people move into research in nanotechnology.
10) This method should be looked upon as the most progressive one.

**Language Development**

8.Agree or disagree with the statements given below. The following phrases may be helpful:

*I doubt that (if) …* *Exactly. Quite so.*
*It's hardly likely that …* *That's right. I hold a similar view about …*
*That's wrong, I can't agree that …*
*Quite the contrary.* *I might as well add that …*
*I don't think so.* *I entirely agree that …*

1) Nanoparticles don't exist in the natural world.
2) Nanoparticles have been created for thousands of years as products of food cooking.
3) Titanium dioxide and zinc oxide become transparent at the nanoscale.
4) Manufactured nanoparticles are typically products in their own right.
5) Nanoparticles are often defined as particles of more than 100nm in diameter.
6) The optical properties of the particle can be finely tuned depending on its size.
7) Nanoparticles have a range of potential applications.
8) The optical properties of the particle can't be tuned depending on its size.
9) Nanoparticles don't exist in the natural world.
10) Nanoparticles can also provide a large surface area and hence enhanced activity.
11) One of relevant potential applications of the nanoparticles can be catalysts.

9. Read the text again. Render it according to the following scheme:

- the title of the text is …
- the text tells/ runs about …
- the main/ central idea is …
- to put it in a few words …
- the aim of the text is to tell the reader about …
- according to the text …
- I support the author's idea …
- I don't quite agree with the author's point of view concerning …
- I'm going to add …
- I'd like to point out the following facts that were new to me …
- in conclusion I'd like to say …

10. Translate in writing paragraphs 6-7 from the text.

11. Prepare a report on the topic "Potential Applications of Nanoparticles".

**Scanning reading**

12. Read the following text once without a dictionary. Try to catch the main ideas. Retell the text briefly in English.

**NANOSTRUCTURES IN NATURE**

If we look closely, we can notice that many plants and animals around us have developed special features that are at the nanoscale level. Let's examine some of the ways in which nature has used nanostructures.

A moth's eye has very small bumps on its surface. They have a hexagonal shape and are a few hundred nanometers tall and apart. Because these patterns are smaller than the wavelength of visible light (350-800nm), the eye surface has a very low reflectance for the visible light so the moth's eye can absorb more light. The moth can see much better than humans in dim or dark conditions because these nanostructures absorb light very efficiently. In the lab, scientists have used similar man-made nanostructures to enhance the aborption of infra-red light (heat) in a type of power source (a thermo-voltaic cell) to make them more efficient!

On the surface of a butterfly's wings are multilayer nanoscale patterns. These structures filter light and reflect mostly one wavelength, so we see a single bright color. For instance the wings of the male Morpho Rhetenor appear bright blue. But the wing material is not, in fact, blue; it just appears blue because of particular nanostructures on the surface. More precisely, the nanostructures on the butterfly's wings are about the same size as the wavelength of visible light and because of the multiple layers in these structures optical interferences are created. There is constructive interference for a given wavelength (around 450nm for the Morpho Rhetenor) and destructive interferences for the other wavelengths, so we see a very bright blue color. In the laboratory, many scientific instruments use this same phenomena to analyze the color of light.

The edelweiss (Leontopodium nivale) is an alpine flower which lives at high altitudes, up to 3000m / 10,000 ft, where UV radiation is strong. The flowers are covered with thin hollow filaments that have nanoscale structures (100-200nm) on their periphery. They will absorb ultraviolet light, which wavelength is around the same dimension as the filaments, but reflect all visible light. This explains the white color of the flower. Because the layer of filaments absorbs UV light, it also protects the flower's cells from possible damage due to this high-energy radiation.

(From "Nanostructure in Nature" by Sandrine Martin, Univ. Mich. // http://www.nnin.org/news-events/spotlights/nanostructures-nature)

# MODULE 7

## Pre-reading

1. Check that you know the meaning of the following words. Use the dictionary where necessary.

| | | | | |
|---|---|---|---|---|
| feasibility | circuit | shift | require | diagnosis |
| artificial | attain | disease | store | reverse |
| overall | density | malignant | mapping | propel |
| spatial | cellular | establish | duration | fuel |
| constitute | endow | tissue | sufficient | fluid |

## Reading

2. Read the text.

### NANOROBOTS AND SUBCELLULAR SENSING

Order-of-magnitude feasibility calculations indicate that nanorobots (artificial machines with overall size of the order of a few micrometres or less in all spatial directions and constituted by nanoscopic components with individual dimensions in the interval 1-$10^2$ nm) are physically possible.

Starting from the reasonable assumption that the current evolution of integrated circuits (ICs) will continue in the next 10 years, the IC will attain a density on the scale of 0.1 Tbit $cm^{-2}$. In this case chips with size of the same order as the cellular (say 10x10x1 $\mu m^3$) one could host a number of devices (say $10^5$) large enough to allow cellular sensing. Endowing these chips with functions (like motion, sensing, etc.) at the reach of nanotechnology would allow the preparation of nanorobots able to produce a shift of paradigm in medicine. Assuming temporarily the validity of the above scenario, such a development will eventually allow the production of the personal physician (PP), whose availability will finally give physi- cians the most potent tools imaginable to conquer human disease, ill-health, and aging.

Of course any major technological progress requires an adequate economic driving force to fuel the development. The potential market of the PP (of the order of $10^{10}$ systems, each of higher value than that of personal computer, PC) seems sufficient for that. The PP is constituted by two parts: a central unit, stably implanted in the organism, and a fleet of squads of shuttles, each squad being specialized to the different tissues and organs.

Each shuttle is a self-propelled nanorobot, able

- to take energy from the environment,
- to recognize and dock the target cell,
- to sense its membrane and neighborhood,
- to recognize its health state,
- to store the information,
- to transfer it to the central unit, and eventually (once allowed) to destroy the malignant cell.

At the present stage of knowledge, the hypothesized nanorobot is certainly far from being producible, but it is not an (irrational) dream because most of the critical steps required for its preparation have already been established.

Exploring the whole cell surface with a step of $10^3$ nm would imply the collection of $10^3$ data ($10^2$ regions times 10 metabolites) for the chemical map of the cell surface. Assuming that each measurement requires 0.1 s (including positioning), mapping the entire cell would require approximately $10^2$ s. The choice of the set of metabolites is characterstic of the target tissue. If the time evolution of a normal cell is known, exploring it for a duration lasting approximately $10^3$ s (about 1% of the characteristic cellular lifetime in mammalian tissues) is most likely sufficient to recognize if the cell is undergoing a physiological or pathological path. Assigning the comparison to the portion of logic not involved in memory, the device will be able to establish (with a certain accuracy) the health state of the cell. If the analysis of a cell requires indeed $10^3$s, in one year the nanorobot will be able to test approximately $3x10^4$ cells; in a tissue of 1 kg it will be able to explore approximately 3 parts per million of the whole tissue. The population of the family of nanorobots must be so chosen as to have an adequate statistical coverage of the tissue. Once ill cells have been recognized, several strategies are possible: to insist over a more prolonged time to confirm the diagnosis, or to explore nearby cells to determine their health states. Genetic algorithms of research will drive the device toward zones of minimum health. Once a nanorobot has confirmed the diagnosis of a pathology, it will drift toward, and eventually dock, the central unit (with complexity on the 10-$10^2$ Gbit scale) where the data on ill cells will be reversed. The central unit will collect information from all the specialized devices, and will eventually inform the physician (by calling its cellular phone) providing detailed information on the organism state.

The realization of such a complex system requires the solution of a lot of problems, covering biomimesis, power supply, propulsion, and data transmission. Biomimetic coatings designed not activate immune response of the organism are at the reach of the current technology, as shown by the several demonstrators of lipid monolayers or bilayers (mimicking biological membranes) supported on solid or polymer surfaces on even large areas. Of course, the supported films are only weakly bound and are thus poorly stable; a larger stability, however, can likely be achieved by bonding covalently (e.g., via silanization) to the sensor surface molecules with carboxylic terminations, mimicking the outer surface of cells.

Supplying power to such a complex system is not trivial and most likely requires different solutions at different levels. The power required for the central unit is macroscopic and may be supplied either by external sources (batteries, electromagnetic coupling) or by implanted generators (stochastic microelectromechanical generators). More difficult is to supply power to the shuttles that, in view of their size ($10^2$ $\mu m^3$), do not tolerate such features.

For fuelling and propelling nanorobots hybrid solutions must necessarily be found. An arrangement where the motion is imparted by the derivatization of the nanorobot with biomotors can be hypothesized: for instance, Montemagno and Bachand have reported the construction of nanomechanical devices powered by biomolecular motors, Kim and Breuer have described the successful use of live bacteria as mechanical actuators in microfabricated fluid systems, and Behkam and Sitti have exploited bacterial flagella for propulsion and motion control of microscale objects. An enormous advantage of this solution is the fact that the motion does not require an alien input of energy for that the chemical energy available in the organism (in the form of adenosine triphosphate, ATP) can be exploited. The same form of energy can also be exploited for powering the electrical circuitry, because biomotors are reversible and can operate as engines too.

At present wireless transmission of data from the nano-robot to the central is seemingly insurmountable: radio-frequency transmission requires indeed an antenna whose size is most likely on the millimetre length scale. This practical impossibility requires that the shuttle periodically returns to the central unit to feed back it with the information on cellular health state.

In this light, other (likely more efficient) organizations are possible. For instance, one can imagine that in each squad the information is transported and reversed to a nearby stably implanted local unit where it is elaborated and transmitted via radio frequency to the central unit for the final elaboration in the light of the inputs coming from the other local units. After that, the relevant information is eventually transmitted to the external world.

Allowing the nano-robot to recognize the health state of the cell with relatively few parameters (say 10) on relatively few regions (say $10^2$) over a relatively short time (say $10^2$s) requires in any case a sufficiently simple built-in model of “standard cell”.

(From http://www.asdn.net/asdn/life/nanorobots.shtml)

**Vocabulary Practice and Grammar Revision**

3. Find the following in the text:

клеточная чувствительность
габаритные размеры
составленные из наноскопических компонентов
разумное предположение
достигнут плотности
можно разместить достаточно большое число устройств
наделяя эти чипы функциями
смена парадигмы в медицине
победить человеческие болезни
разрушать болезнетворную клетку
хранить информацию
составление плана целой клетки
установить состояние здоровья клетки
подтвердить диагноз
каждая порция информации

4. Answer the questions:

1. What makes possible to host in a cell a number of devices large enough to allow cellular sensing?
2. Why are nanorobots able to produce a shift of paradigm in medicine?
3. What is each shuttle (a self-propelled nanorobot) able to do?
4. What does make possible to believe that the hypothesized nanorobot is not an (irrational) dream?
5. What is the way of recognition if the cell is undergoing a physiological or pathological path?
6. What will do a nanorobot that has confirmed the diagnosis of a pathology?
7. What kind of problems does the realization of a system of nano-robots require to solve?

5. Make up the sentences of your own with these verb-phrases:

to be of interest (value, importance, significance)
to come into use (action, play, into being)
to go into play (service, practice, particulars)
to bring into action (use)
to put into (use, operation, practice)
to take (advantage of, care of, part in) place, into account of, into consideration
to give (consideration, mention, account)
to be in (excess, progress, a position, under way)
to be interested in (natural sciences, the problem, research)
to be under way (the study, programme, search, research)
to deal with (people, the problem, animals, the study)

6. Translate the sentences into Russian:

1) Research work and experimental investigation are constantly in progress to find materials with protections better than those in use.
2) So we are now in a position to determine these properties.
3) The study of space on a large scale with scientific instruments is under way.
4) The protection of seas from drift netting is of great

significance.

5) We cannot say with certainty how the solar system had come into being.

6) A new radar went into service last year.

7) When planning communication in space we must take into account the ionosphere.

8) The application of new methods let give an account of devastating effects on the environment.

9) Nanotechnology deals with various kinds of nanoparticles.

7. Work with a partner. Make as many words as you can by adding prefixes (e. g. re, un, in, etc.) or suffixes (e. g. tion, ence, ic, etc) to the words below:

inform
important
acid
response
diverse
populate
science
depend
oxide
construct
act
protect
produce
number
new

8. Fill in the correct preposition, then choose any five of them and make sentences:

1. to account … sth/sb
2. to be important … sth/sb
3. to be optimistic/pessimistic … sth
4. to be available … sth/sb
5. investment … sth/sb
6. concentration … sth

7. a concentration … sth
8. to get benefit … sth
9. to have the benefit … sth
10. to depend … sth
11. to consist … sth
12. to be interested … sth/sb
13. a variety … sth
14. to be accurate … sth

9. Choose the correct future form:

1. Next month I ………. a conference in Belgium on nanotechnology.
2. **A** is taking part **B** will have been taking part **C** takes part
3. This time next Friday, we ………… an experiment.
4. **A** will make **B** will be making **C** are going to make
5. We hope our assumption ………… right.
6. **A** will be **B** will have been **C** is going to be
7. These observations ………… by the end of the year.
8. **A** will be finish **B** will have been finished **C** are going to be
9. By the end of the year, Tom ………. at the laboratory for ten years.
10. **A** will work **B** will have been working **C** will be working
11. This time next Friday, we ………… an experiment.
12. **A** will make **B** will be making **C** are going to make
13. She ………. an experiment in nanofabrication this year.
14. **A** will make **B** will be making **C** is making

**Language Development**

10. Comment upon the following problems, use the expressions given below:

- I suppose you know that … .

- I hope you will find it of interest to learn (that) … .
- I would like to start by describing … .
- According to what I know … .
- It should be mentioned (that) … .
- I would like to emphasize (that) … .
- As to me, I am of the opinion (that) … .
- I wish to finish by emphasizing (that) … .

1. Order-of-magnitude feasibility calculations indicate that nanorobots are physically possible.
2. At the present stage of knowledge, the hypothesized nanorobot is certainly far from being producible, but it is not an (irrational) dream.
3. For fuelling and propelling nanorobots hybrid solutions must necessarily be found.

11. Discuss in groups of three one or more of the important questions raised in the text. Then present your ideas to the whole group.

12. Discuss the ideas suggested by the author in the text. How popular is the idea of the creation of nanorobots in your country? How do you feel about it?

13. Write a summary of the text in 100-120 words.

14. Translate in writing paragraphs 10-12 from the text.

**Scanning reading**

15. Read the following text once without a dictionary. Try to catch the main ideas. Retell the text briefly in English.

## MEDICAL NANOROBOTS

The birth of biomolecular science and new manufacturing techniques is helping to advance the miniaturization of devices from micro to nanoelectronics.

A first series of nanotechnology prototypes for molecular machines are being investigated in different ways, and some interesting device propulsion and sensing approaches have been presented.

More complex molecular machines, or nanorobots, having embedded nanoscopic features may provide new tools for medical procedures. Sensors for biomedical applications are advancing through teleoperated surgery and pervasive medicine.

The use of microdevices in surgery and medical treatments is a reality which has brought many improvements in clinical procedures in recent years. For example, catheterization has been used as an important methodology for many cardiology procedures and aneurysm surgery.

In the same way as the development of microtechnology in the 1980s has led to new tools for surgery, emerging nanotechnologies will similarly permit further advances providing better diagnosis and new devices for medicine through the manufacturing of nanoelectronics based on new CMOS technologies.

Nanorobots may be considered a new possibility for medical instrumentation to solve many problems in health care, including cardiology interventions, medical analysis, cancer early diagnosis, diabetes monitoring, and minimally invasive brain surgery.

For effective manufacturing progress it is considered a nanorobot architecture design using embedded devices with nanoelectronic circuits based on RF CMOS transducers, to integrate the sensing, communication, energy transfer, and actuation for the nanorobots as the most effective way to accomplish the work to advance molecular machines.

Devices based on CMOS are achieving 45nm sizes, with functional sensors and actuators being produced with sizes equal and smaller than 500nm. The correct architecture for medical nanorobots may include the minimal number of embedded devices for its effective application, having embedded sensors and actuators for specified tasks.

It is important to define actual capabilities to enable Nano-Build Hardware Integrated Systems, establishing how to enable pathways to help on research and development of nanorobots based on the present stages of nanotechnology development.

Nanoelectronics integrated circuits using nanowires, nanotubes and photonics are leading to smaller sizes on complex devices. Allied with this fact, the mobile phone as a widely used device in everyday life could be applied as a source of coupling energy and data transmission for communication, control, and energy supply for the operation of a nanorobot inside a human body.

(From “Medical Nanorobot Architecture Based on Nanobioelectronics” by Adriano Cavalcanti, Bijan Shirinzadeh, Robert A. Freitas Jr. and Luiz C. Kretly // http://www.benthamscience.com/nanotec/samples/nanotec1-1/Cavalcanti)