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Erasmus+

Odyssey
Oxford Debates for Youths in Science Education

Cognitive Field: Nanotechnology, Health and Environment
Topic: "The use of nanomaterials causes serious health problems in humans"

Worksheets and Material
Student's Edition

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ENERGIA AVASTUSKESKUS ENERGY DISCOVERY CENTRE

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Cognitive Theory and Correlation with the Curriculum

Subject: Nanotechnology, Health and Environment

Topic of debate: The use of nanomaterials causes serious health problems in humans

Terminology

• **Nanomaterials:** Mechanical nanomaterials (engineered nanomaterials, ENMs) are substances or materials whose size ranges between 1 and 100 nm (nanometers, 10-9 meters - various classifications: zero dimension (0D) <100nm, such as nanoparticles and quantum dots, one-dimensional (1D) <100nm, such as nanotubes, fibers and nanowires, two-dimensional (2D) <100 nm minutes and ultra-thin films, coatings, multilayer structures, etc.). Nanomaterials have specialized physicochemical properties and specific, different (where applicable) properties compared to larger particle materials. The need for new, advanced materials and systems with new properties and behaviors, led to the creation of nanomaterials. The need for new, advanced materials and systems with new properties and behaviors led to the creation of nanomaterials.
Procedures for the production of nanomaterials include: a) mechanisms for depositing atoms or molecules from the gas phase on the surface of a solid material (bottom-up approach) or b) the creation of a specific structure through e.g. ion bombardment, lithography (top down approach) (Vlachogianni et al. 2014, Nanomaterials Engineering and Nanotechnology Applications, http://bit.ly/2LyAr9H; Haritidis & Kordatos from the website of the course Nanomaterials and Nanotechnology).

•**Nanotechnology:** It is the study and technological application of extremely small objects, which are applied in all other fields of science, such as chemistry, biology, physics, materials science and engineering, pharmacology, etc. Nanotechnology is defined as the field of engineering applications that use molecule-sized structures. The scale for measuring these structures is the nanoscale and gives their sizes in nanometers (nm), that is, in multiples of one billion meters. For the most part, in the field of nanotechnology, interest structures are usually less than 300nm in size. By comparison, the cross section of a human hair is about 60,000nm, a DNA molecule 2 to 2.5 nm, and a water molecule almost 0.3nm. The actions of nanotechnology include the design and construction of materials at the level of the molecule and the individual, as well as the various applications of these materials. Matter, at the levels considered by nanotechnology, exhibits quantum properties, completely different from the properties of macroscopic quantities that surround man in his daily life. Therefore, nanotechnology has an interdisciplinary character, as it is perfectly combined with other sciences whose structures are measured on the same scale (nanoclimate), such as quantum physics, chemistry, biology, computer science and microelectronics, etc.

• **(The) Foulerenia:** Each molecule is in the form of a regular twentieth century, consists of 60 C atoms and resembles a soccer ball. See the figure next to and http://bit.ly/2IUA7OA.

• **Carbon nanotubes:** They are concentric graphite cylinders, closed at each end with five-membered rings. They were discovered in 1991 by Sumio Iijima. Nanotubes can be multifocal with a central tube surrounded by one or more layers of graphite or monofilament, where there is only one tube and no extra layers of graphite. When nanotubes are grouped, we have the so-called nanotube arrays (Wikipedia). See the figure next to it here http://bit.ly/2ZBDVea, http://bit.ly/2XVMtMJ

• **Nanotoxicity:** It is the toxicity of nanomaterials, while nanotoxicology is the research about the toxicity associated with nanomaterials.

• **Bioavailability:** Bioavailability refers to new drugs and bioavailability in essentially similar drugs, those whose patent protection has expired and are manufactured by any pharmaceutical company. The definition of bioavailability as determined by the Academy of Pharmaceutical Sciences is 1.2: "The measurement of the relative amount of a given drug that reaches the general blood circulation in relation to the rate at which it occurs." (Source: IFET)

• **Oxidative stress:** Oxidative stress in a cell or organism is called the pathological condition, which results from the imbalance between the levels of anti-oxidative mechanisms and oxidative factors (active forms of oxygen, nitrogen and free radicals) .a. 2009,)

• **Homeostasis:** With this self-adjusting mechanism the programmed temperature of the iron is kept constant, regardless of the temperature of the external environment. Similar mechanisms of self-regulation are found in living organisms. In order to function properly, they must be able to maintain their internal environment (composition and amount of liquids, temperature, pH, etc.) relatively stable, regardless of the conditions of the external environment in which they live. This ability is called homeostasis and, in order to achieve it, energy is required. (School Biology Guide C C, Chapter 4).

Source: Singh, N. A. (2017). Nanotechnology innovations, industrial applications and patents. Environmental Chemistry Letters, 15 (2), 185–191. doi: 10.1007 / s10311-017-0612-8.
Additional Material from the European Union: https://ec.europa.eu/research/industrial_technologies/pdf/nano-brochure/nano_brochure_el.pdf

Lesson 1 Introductory Seminar - Webinar

Introductory questions: During the 1st lesson but possibly after the completion of the 1st lesson, where the introduction to the topic of controversy was made (through the material of the presentations and videos on the webinar) the following introductory questions were asked which will be used as based on the principles of the second lesson.

1) Nanoclimate. What is it?
2) What sciences are involved in the creation of nanomaterials?
3) What are the materials that nanotechnology creates?
4) Do nanotechnologies created by nanotechnology help people grow and prosper?
5) Problems with human health arise from the use of nanomaterials?
6) Are the mechanisms by which nanomaterials create a problem for human health known?
7) Are there ways to control or prevent possible problems with nanomaterials?
8) Have materials or nanotechnology technologies been created that help human health?
9) Are there positive economic effects from the development of nanotechnology?

Students' answers

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Activity 1

Based on your preparation for resolving the dispute over whether nanomaterials cause human health problems, prepare a series of arguments, classifying them into those that are clearly in favor of the resolution, against the resolution and the arguments that can used on both sides - that is, they are controversial. The questions given to you by the professor in the "Introduction" support the creation of the pros, the controversies and the votes against.

FOR	GREY AREA	AGAINST

Activity 2

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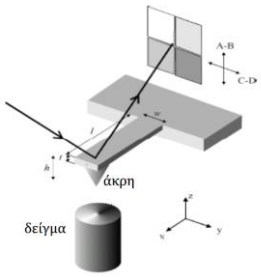
REAL LIFE EVENTS

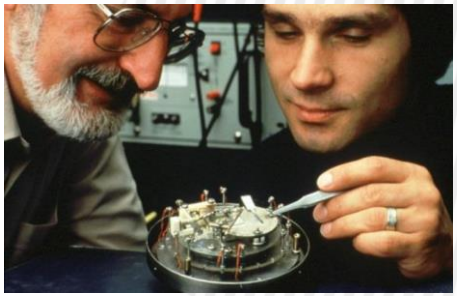
Below you will find the information cards, story cards and question cards. Read carefully and analyze, in order to formulate your arguments through the answers to the questions.

INFO CARD 1

Individual Force Microscopy (IFM)

Nanotechnology has allowed the development of tools and instruments at the individual level. One such case is the **atomic force microscope** (*IFM*) - left photo - which is based on measuring forces instead of measuring current. For this reason, a leaf spring with a spike is used, which scans the surfaces with a certain pressure during contact. Another technological application is the **Sweeping Tunnel Microscope** - photo right - which was developed in 1982 in Switzerland, at the IBM Research Laboratory in Rüschlikon and received the Nobel Prize in Physics in 1986. The STM made it possible for the first time to "see "or" scan "people.

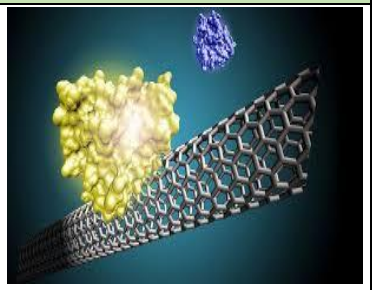




Source: Project *QUANTUM SPIN-OFF* http://qs-project.ea.gr/en/content/resources .
In the right photo: Heinrich Rohrer και Gerd Binnig with their first tunnel sweeping microscope (source: IBM)

INFO CARD 2

Nanotubes and cancer



Long fiber carbon nanotubes are a subtype of nanotubes. They are used to make extremely strong but lightweight materials, which are widely used in a variety of industrial and consumer products, including sports equipment (helmets and bicycles, aircraft, sports cars) and computer motherboards.

However, "unlike previous short-term studies, this is the first time that the effects of long and thin carbon nanotubes leading to mesothelioma have been monitored in mice for many months," says the author Marion MacFarlane, professor at the Medical Research Council (MRC) at the Toxicology Unit in Leicester, UK.
In animal experiments, the researchers placed long carbon nanotubes in the pleura, the area around the lungs, where mesothelioma develops in humans. "In this way, we monitored changes in the pleura during the development of the disease, observing stages of chronic inflammation, activation of pre-oncogenic signaling pathways, and eventual inactivation and / or loss of genes, which are the gateways to cancer development," MacFarlane mentions.
The mesothelioma induced in mice by long carbon nanotubes was in many ways similar to tumor samples from patients (humans).

Source: The subset of carbon nanotubes carries a risk of cancer similar to asbestos in mice. https://www.sciencedaily.com/releases/2017/11/171106132018.htm

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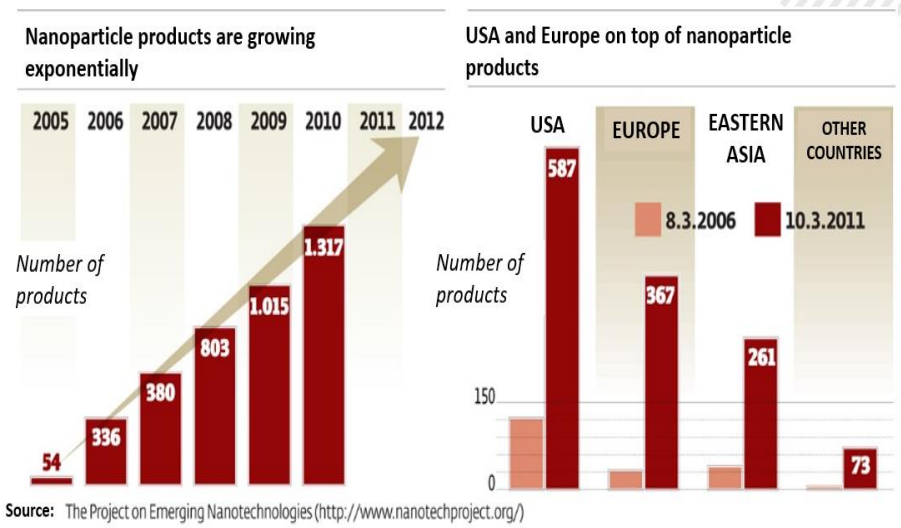
INFO CARD 3

Production of new products from nanomaterials and production countries



Despite the industrial production of nanomaterials, there has been no shortage of raw materials for their production. One reason is the tiny ... individual quantities required to produce nanoparticles. Of course, there are no clear production numbers from the production companies - which creates problems in assessing the environmental impact.

Source: Piccinno, F. et al. (2012). *Industrial production quantities and uses of ten engineered nanomaterials in Europe and the world*. Journal of Nanoparticle Research, 14(9). doi:10.1007/s11051-012-1109-9 & Tsoli Th. (2012), How much does the spread of nano-products threaten our health?@ tovima.gr

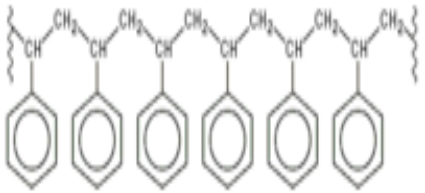
INFO CARD 4

Biocides and Nanotechnology

The majority of mortality and morbidity in developing countries is associated with infection by pathogens present in the water consumed, while many species of insects that reproduce in water, in turn cause many diseases (malaria, dengue fever, yellow fever etc.). Water chlorination is currently the main choice in the fight against pathogenic microorganisms. For chlorination of water either chlorine gas (Cl) (for large plants) or chlorine compounds (for small plants) are used. There is, however, a risk from the presence of free chlorine (Cl) in the water as it is very toxic and corrosive.

Advanced methods have always remained in demand for the removal of permanent organic pollutants from wastewater and groundwater. Photocatalytic methods have proven to be very effective. These methods are based on the production of highly active hydroxyl (OH) and O2- radicals using ultraviolet (UV) / titanium dioxide (TiO2) radicals, a combination that leads to degradation.

Along with developments in nanotechnology applications, photocatalysis seems to achieve the degradation and mineralization of water containing organic pollutants, using immobilized TiO2 nanoparticles. For photocatalytic treatment of water containing organic pollutants, the immobilized nano-TiO2 catalyst has been shown to be particularly effective in (photo) reactors using ultraviolet (UV) radiation.



polystyrene

Source: Loukas G. Pananikolaou K., (2015), Use of nanotechnology methods in water purification and desalination. Thesis, ATEI West Of Greece,

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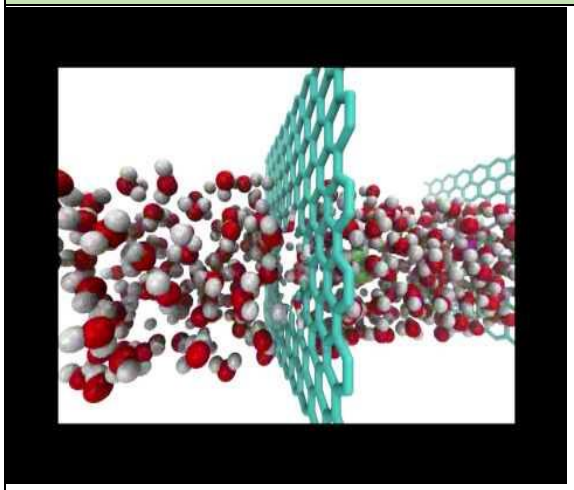
INFO CARD 5



Water desalination

Nanoscale membrane processes are becoming increasingly popular for water desalination. The minimum thermodynamic energy required by the method for desalination, the minimum polarization resistance, the zero viscosity of the membrane and the almost zero energy losses for the cleaning of the membrane are characteristic and show the superiority of these new materials over other previous methods.

The main desalination applications include the use of forward osmosis, hydration-dehumidification cycles, and the trapping of solar energy for thermal distillation methods, and the use of nanoscale transport phenomena is now being used to maximize yields.

All approaches have their own advantages and disadvantages, including energy consumption challenges, waste management, construction and cost issues, and the possible outflow for a given water quality.

Source: Loukas G. Pananikolaou K., (2015), Use of nanotechnology methods in water purification and desalination. Thesis, ATEI West Of Greece,

INFO CARD 6

Cosmetology – Cosmetics

Numerous cosmetic products on the market (from companies such as Lancôme, Kara Vita, Nano-Infinity Nanotech, L'Oréal) based on nanomaterials are already on the market. Products such as moisturizers, cleansers, anti-wrinkle creams, sunscreens, Liposomes are used in the production of cosmetics as they are biocompatible, biodegradable, non-toxic, flexible and can easily and effectively "trap" the active ingredients.

Source: Singh, N. A. (2017). *Nanotechnology innovations, industrial applications and patents.* Environmental Chemistry Letters, 15(2), 185–191. doi:10.1007/s10311-017-0612-8 Photo:pop herald)

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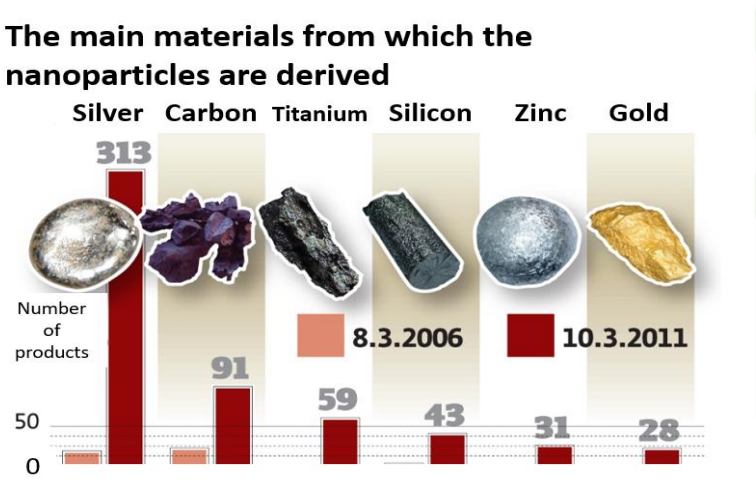
INFO CARD 7

Nanomaterials

What can a refrigerator, a wall paint, a deodorant, a sunscreen, a pair of socks, a food package and a tennis ball have in common? Answer: the presence of nanoparticles in their components. These tiny particles are already a reality in many people's daily lives.

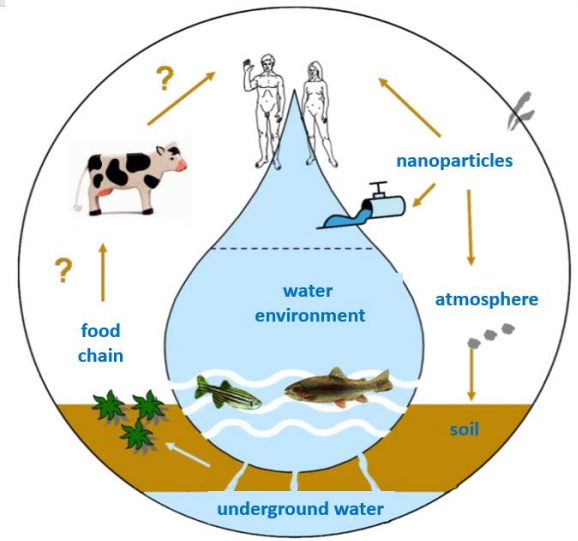
It is estimated that more than 1,300 everyday products on the world market contain particles of different materials, made at the nanoscale, in order to have improved properties compared to conventional ones. Another "gray zone" is what can happen with the release of nanoparticles into the environment when the life cycle of the products that contain them ends.



Source: & Tsoli Th. (2012), How much does the spread of nanoproducts threaten our health? @tovima.gr

INFO CARD 8

Nanoparticles and environment



Most products that contain nanomaterials, when the life cycle ends, are discarded in the environment. There, nanomaterials, through the water cycle, the nitrogen and carbon cycle, and especially through the food chain, are transported and migrated to large populations of living beings - and humans.

It is a fact that the release of nanoparticles into the environment requires (new) regulations and continuous checks: in the phase of disposal, in the phase of decomposition of products with ENPs, etc., in order to determine and prevent the possible release of such particles into the atmosphere (mainly when burning products)

Source: Frimmel F.H. et al. (2010), *Nanoparticles in the Water Cycle: Properties, Analysis and Environmental Relevance*, ISBN 9783642103179, Springer-Verlag Berlin Heidelberg & Tsoli Th. (2012), How much does the spread of nanoproducts threaten our health? @tovima.gr

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INFO CARD 9

Tolerable or permissible nanoparticle values

Exposure limits to nanoparticles (especially for professional workers in areas with high exposure to nanoparticles) and reference values, is something that is constantly updated.
Below we see what various organizations around the world are proposing.

Nanomaterial type	**BSI** (United Kingdom 2007)	**IFA** (Germany 2009) & **SER** (Netherlands 2012)	**SWA** (Australia 2012)	**NIOSH** (USA 2013)
Fibers	0.01 fibers/cm^3	0.01 fibers/cm^3	0.1 fibers/cm^3	0.007 mg/m^3
Granular	20 000 particl./ cm^3	40 000 particl./cm3	0.3 mg/m^3	0,003 mg/m^3

Source: Pietroiusti A. et al. (2018), *Nanomaterial exposure, toxicity, and impact on human health*, DOI: 10.1002/wnan.1513, WIREs Nanomed Nanobiotechnol. 2018;e1513. https://doi.org/10.1002/wnan.1513

INFO CARD 10

Uses of nanomaterials

The uses of nanomaterials cover a wide range of applications (research, industry, everyday life). More specifically, metal oxides such as Titanium (TiO2), Pyrite (SiO2,) Aluminum (Al2O3,), Demetrius (CeO2), Iron (FexOx,), etc. are used in the collection, sorting and processing process (such as e.g. sieving) materials and in natural and / or chemical materials manufacturing processes, in processing and friction and in finishes. Note that quantum dots of Cadmium (Cd) - Zinc (Zn) - Selenium (Se) are used in ultrasound technology. Finally, laboratory and field studies have shown that PRBSs (ZVMs) such as Fe, Cu, Al, Al, Si, Z, Mg are a promising strategy for organ and organ removal. pollutants in a contaminated subsoil environment.

Source: Pietroiusti A. et al. (2018), *Nanomaterial exposure, toxicity, and impact on human health,* DOI: 10.1002/wnan.1513, WIREs *Nanomed Nanobiotechnol*. 2018;e1513. https://doi.org/10.1002/wnan.1513

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INFO CARD 11

Nanotechnology and development

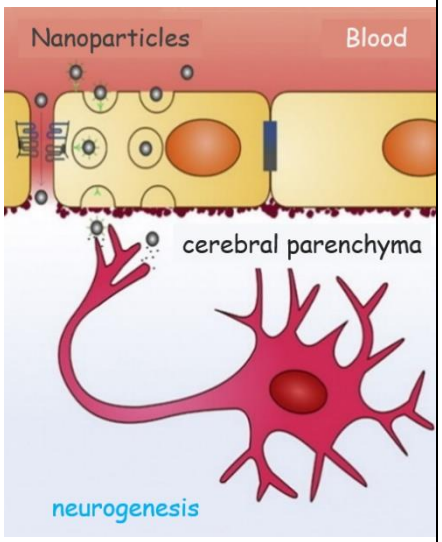
According to the report, between 2009 and 2010, investments by companies and institutional investors in research and development in nanotechnology reached $ 10 billion, respectively, while governments spent $ 15 billion. The leading areas, from a very early age, in research and nanotechnology are: transport, aeronautics and space, nanotechnology, applied electronics, energy production, food, food packaging, etc.

Source: OECD (2012), *Working Party on Nanotechnology*, DSTI/STP/NANO(2012)15, OECD/NNI International Symposium on Assessing the Economic Impact of Nanotechnology Background Paper 2: Finance and Investor Models in Nanotechnology, & NNI (2004) *Nanotechnology in Space Exploration*, Report of the National Nanotechnology Initiative Workshop, August 24–26, 2004, Palo Alto, CA

INFO CARD 12

Nanotechnology & Medicine

Nanomedicine is an emerging innovative field with new pioneering treatments, where treatment can potentially 'target' a single cell. Materials and techniques used are quantum dots (2.5 - 100 nm), one-dimensional structures <100nm such as nanotubes, nanowires, cantilevers, two-dimensional structures <100 nm such as thin and ultra-thin films, coatings and multilayer structures. Also, the use of Nanoshells (spherical nanoparticles) is developed, which respond with the following 'forms': dendrimers, micelles, liposomes, niosomes, fullerenes. Finally, nanoparticles can enter the body with the aim of the brain 'using' two mechanisms: a) through their inter-synergistic transport through the olfactory epithelium after inhalation and b) through their uptake through the blood-brain barrier (barrier). blood-brain or Blood-Brain Barrier or just BBB - photo)



The blood-brain barrier (BBB) is a multicellular structure and is a critical boundary between nerve tissue and circulating blood. BBB controls the homeostasis of the brain as well as the movement of ions and molecules. Failure to maintain homeostasis results in the collapse of this specialized structure that leads to neuroinflammation and neurodegeneration.

Source: Saraiva et. al (2016). *Nanoparticle-mediated brain drug delivery: Overcoming blood–brain barrier to treat neurodegenerative diseases*. Journal of Controlled Release, 235, 34–47. doi:10.1016/j.jconrel.2016.05.044, & Kwatra Shubhika, 2013, *Nanotechnology and medicine – The upside and the downside*, ISSN 0975-9344 (photo Saraiva et. al 2016)

INFO CARD 13

Nanomaterials and water

Nanotechnology materials have been applied in the purification and desalination of water, helping to maintain good public health. Specific methods used are:

1. in parallel with UV radiation and the use of (nano) catalyst TiO2, (mainly for the decomposition and mineralization of water containing organic pollutants)
2. nanoporous materials (collection of unwanted substances)
3. nanomaterials for use in critical contamination conditions (e.g. high percentages of heavy metals and / or toxic substances in industrial, agricultural, household wastewater)
4. use of zero-strength metals and bimetallic iron systems to reduce toxic pollutants in water. Below is the effectiveness of the first method:

BEFORE

Number of E. coli and Spigellaspp colonies		
Sample	E. coli	Spigella spp.
1	> 960	> 1800
2	> 1000	> 7960
3	> 700	4000
4	> 1500	6000

AFTER

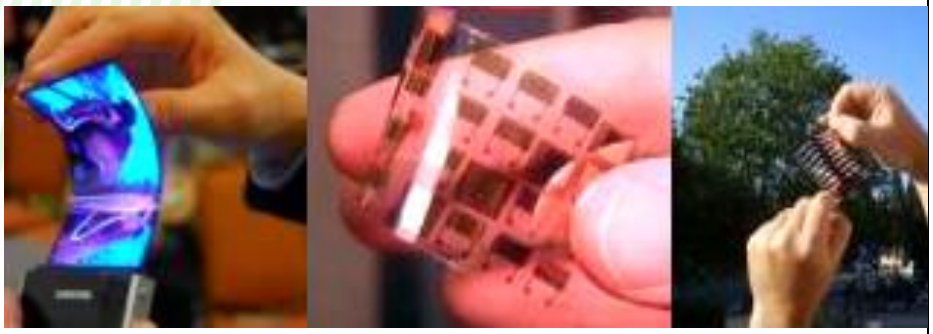
Bacteriological analysis for the treatment of water with rubber shavings and ultraviolet radiation		
Sample	E. coli	Spigella spp.
1	0/100 ml	0/100 ml
2	3/100 ml	2/100 ml
3	0/100 ml	0/100 ml
4	1/100 ml	0/100 ml

Source: Loukas G. Pananikolaou K., (2015), Use of nanotechnology methods in water purification and desalination. Thesis, ATEI West Of Greece

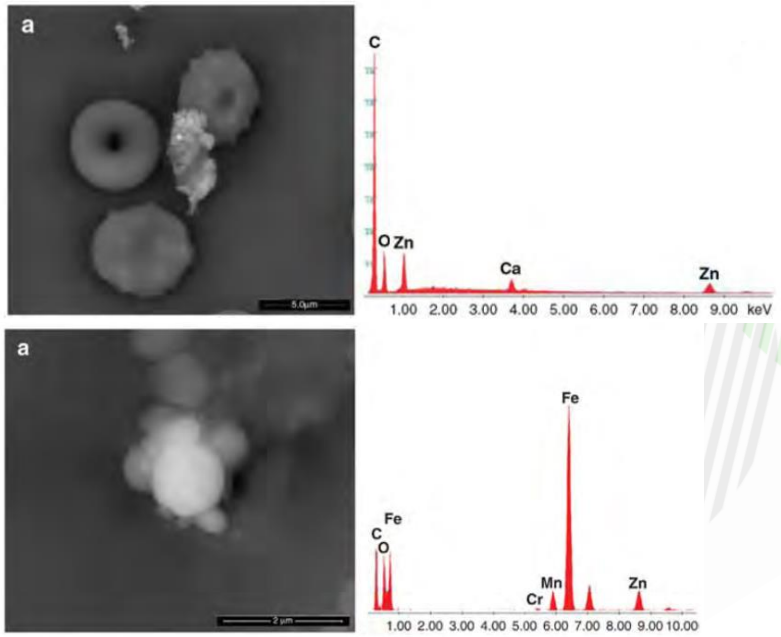
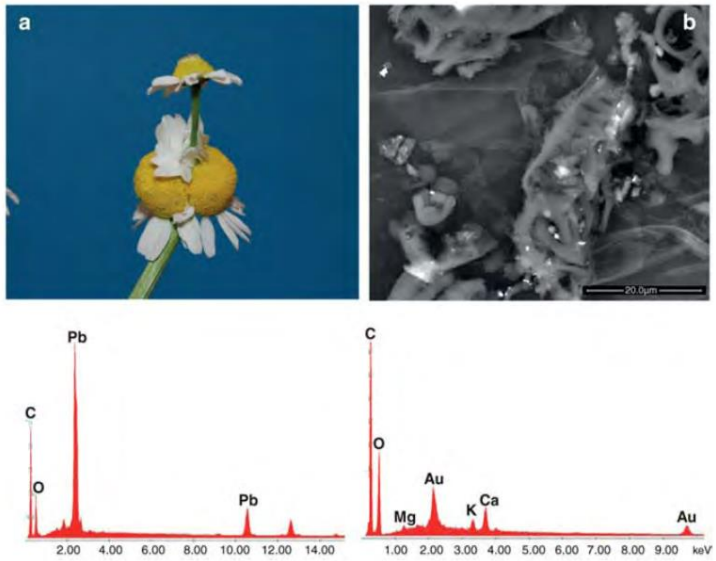
INFO CARD 14

Organic nano-electronics

Organic electronics is one of the fastest growing branches of materials science. The term refers to the study of organic conductive polymers and conductive small molecules as well as their applications in modern electronic deviceç. They are based on the discovery of the conductivity shown by enriched polyacetylene by A. Heeger, A.G. MacDiarmid and H. Shirakawa in 1977 (Nobel Prize in Chemistry 2000). The comparative advantages of this technology compared to the classic silicon technology, are the low cost, (due to the possibility of using new methods and techniques for their development on a large scale e.g. roll-to-roll, inkjet printing), their flexibility, the ease of tailoring of the properties of the materials for specific applications and their low energy consumption.



Source: From the website of DPSM Nanoscience and Nanotechnology of AUTh nn.physics.auth.gr

INFO CARD 15	INFO CARD 16
Nanotoxicity Top photo: Red blood cell with human blood red blood cell and an unusual biological aggregate containing zinc-calcium particle. Bottom photo: Spherical fragments found in a kidney biopsy. The pellets contain iron, zinc, manganese and chromium.  Source: Gatti A.M., Montanari S. (2015), *Case Studies in Nanotoxicology and Particle Toxicology* - Academic Press, ISBN: 978-0-12-801215-4, Elsevier, p. 32,73	**Plant Nanotoxicity** Deformed chamomile flowers. The spectral lines show contamination of lead, gold, calcium, magnesium, potassium.  Source: Gatti A.M., Montanari S. (2015), *Case Studies in Nanotoxicology and Particle Toxicology* - Academic Press, ISBN: 978-0-12-801215-4, Elsevier, p. 254 & Dietz, K.-J., & Herth, S. (2011). *Plant nanotoxicology*. Trends in Plant Science, 16(11), 582–589. doi:10.1016/j.tplants.2011.08.003

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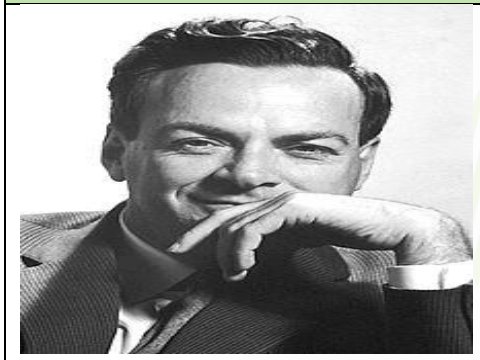
STORY CARD 1	STORY CARD 2
 **Richard Feynman (Nobel Prize in Physics 1965)** “I want to build a billion tiny factories, where one will be a model for the other, which will be put together at the same time. The principles of Physics, based on my estimates, do not contradict the possibility of handling material objects, person-to-person. This plan is not an attempt to violate the laws of nature. It is something that can happen and the reason why this has not yet happened in practice is that we are too big for that.” Source: Excerpt from his lecture series on Nanotechnology, in 1959, entitled "Here's Plenty of Room at the Bottom"	 **G. Biskos (Assistant Professor of Environment, University of the Aegean)** "We can take any material and cut it into very small pieces, with dimensions from 1 to 100 nanometers. Why; Because this way we increase the ratio of the surface to the volume of the material, something very useful, since, in this way we also increase its activity. We are largely unaware of how the properties of the material in nanoclimates can affect the behavior of nanoparticles when they come in contact with living organisms. For example, we have analyzed the behavior of certain materials, such as gold or silver, when they are at the nanoscale level, but no corresponding controls have been performed for the entire range of materials. At the same time, the products, which contain nanoparticles, are subject to controls before their release, but even in this case they are tests that examine side effects based on our current knowledge. Unfortunately, the scientific community does not yet have the technology to determine the properties of nanoparticles, which may be directly related to effects on human health. " Source: Tsoli Th. (2012), How much does the spread of nanoproducts threaten our health?@ tovima.gr

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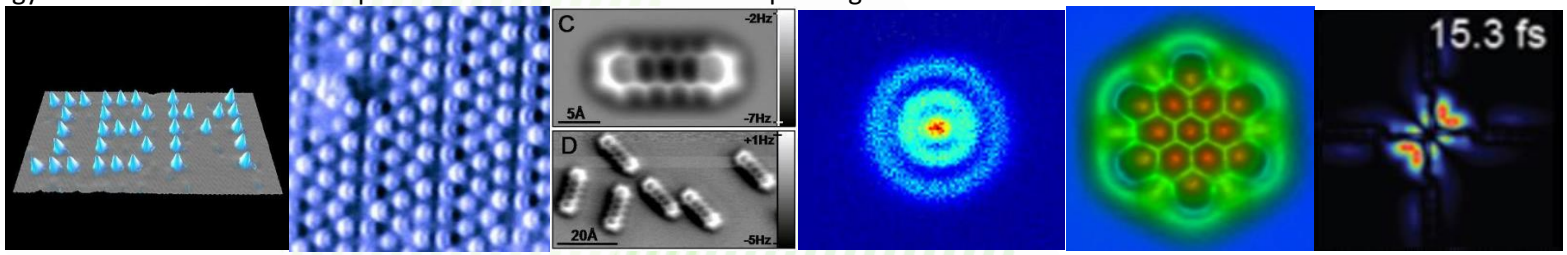
STORY CARD 3

Photographing the .... person & Historical background in nanotechnology

«nanotechnology and manomaterials made possible the PHOTOGRAPHICAL imprinting of the structural elements of matter! See below ....historical flashback!



1993 2006 2009 2013 2013 2014

Richard Feynman introduced the idea of nanotechnology or molecular machines in 1959, with his famous lecture «There's Plenty of Room at the Bottom». In it, it prompted scientists to consider building individual devices, and twenty years later, Drexler published his first advances in nanotechnology. The term "nanotechnology" was coined by Tokyo University Professor Norio Taniguchi in a 1974 document: ». In 1981, Zurich invented the scanning microscope (STM), a non-optical microscope that allows the display of high-density electron beams and can therefore draw conclusions about the existence of individual atoms or molecules on the surface of a network. Fullerenes are allotropic forms of carbon that have recently been discovered. These are spheres-cages with 60, 70 or more C atoms connected to each other in 5-membered and 6-membered rings in a total arrangement of regular chandeliers. The discovery of the fullerenes led to the awarding of the Nobel Prize in Chemistry in 1996 to the three main researchers, Harold W. Kroto, Richard E. Smalley and Robert F.Curl. In 1991, nanotubes (CNT) were discovered. These are concentric graphite cylinders, closed at each end with five-membered rings. Depending on their structure, they can be used as semiconductors in electronics. CNTs are five times less dense than steel and fifty times more powerful than it, and therefore have applications in composite materials, such as car bumpers, etc. "

Source: Dvorsky G. (2013) *The First Image Ever of a Hydrogen Atom's Orbital Structure* @ gizmodo.com http://bit.ly/2WToQTJ & Max Planck Institute (2014) *Physicists Image and Control the Motion of the Two Electrons in a Helium Atom*, http://bit.ly/2WVaPVF & ΙΕΠ (2017) *SUBJECT I: Design for the preparation of Creative Work Indicative Example: Chemistry, 2nd Lyceum*, http://bit.ly/2JLy8xV

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STORY CARD 4

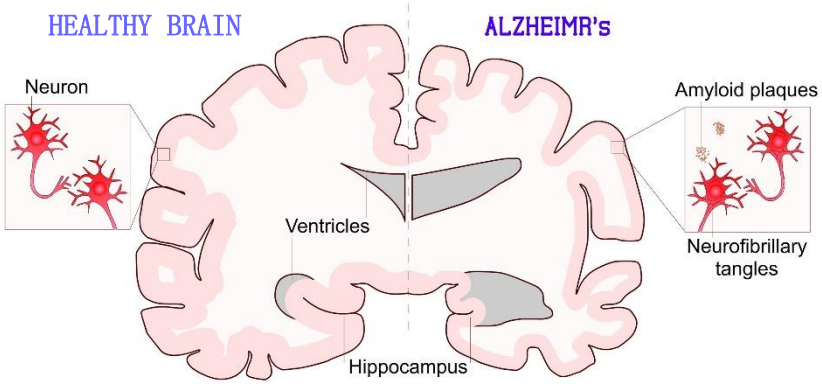
Clinical trials & nanoparticles

The blood-brain barrier (BBB) is a vital boundary between nerve tissue and circulating blood. The unique and protective properties of BBB control the homeostasis of the brain, as well as the movement of ions and molecules. Failure to retain any of these components results in the breakdown of this specialized multicellular structure and, consequently, promotes neuroinflammation and neurodegeneration.

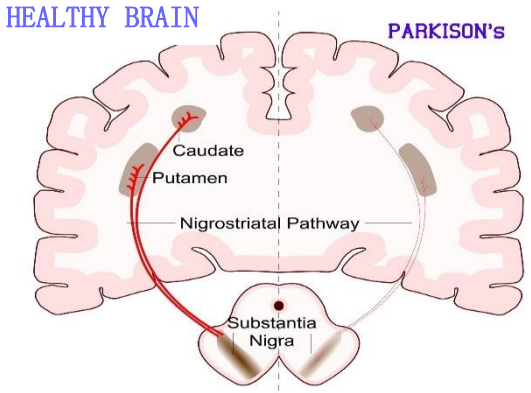
In many high-frequency pathologies, such as stroke, Alzheimer's disease (AD) and Parkinson's disease (PD), BBB is attenuated. However, even a damaged and more permeable BBB can pose a serious challenge to the delivery of drugs to the brain. […] Nanocarriers are small agents with the ability to enclose drugs that provide protection, increasing their release time and providing a temporally and spatially controlled release of their charge at the site of injury after intravenous injection.

The use of nanoparticles (NPs) in preparations capable of encapsulating molecules with therapeutic value, while targeting specific transport processes in the cerebrovascular system, may enhance drug delivery via BBB to neurodegenerative / ischemic disorders and target . …

Dopamine replacement therapies are now the most widely used forms of PD therapy, as they are able to improve motor symptoms. However, the effects on behavior and knowledge are still controversial…. According to this, Pahuja and his colleagues have developed dopamine-laden PLGA nanoparticles (DA NPs) (approximately 120 nm in diameter), which have been able to improve animal behavior, thus reducing amphetamine-induced rotation, without appearing signs of heart-related changes or sudden changes in the brain or periphery.



(Left) In clinical trials, in preclinical animal models, the main pathological signs were found in brain patients with Alzheimer's disease (A) and in the brain and nanoparticle (N) systems used in (A). Its main features (A) are the presence of amyloid and neuromuscular plaques in neurons, which leads to severe neurodegeneration, shrinkage of the cerebral cortex and hippocampus, and enlargement of the ventricles



(Right) Features of Parkinson's disease (P) and nanoparticle (N) systems used in preclinical animal models. The brain with (P) is characterized by a selective loss of dopaminergic neurons essentially nitrin, culminating in the reduction of dopamine in the ribbed body due to degeneration of the dopaminergic nitrostyrene pathway.

Source: Saraiva et. al (2016). *Nanoparticle-mediated brain drug delivery: Overcoming blood–brain barrier to treat neurodegenerative diseases*. Journal of Controlled Release, 235, 34–47. doi:10.1016/j.jconrel.2016.05.044

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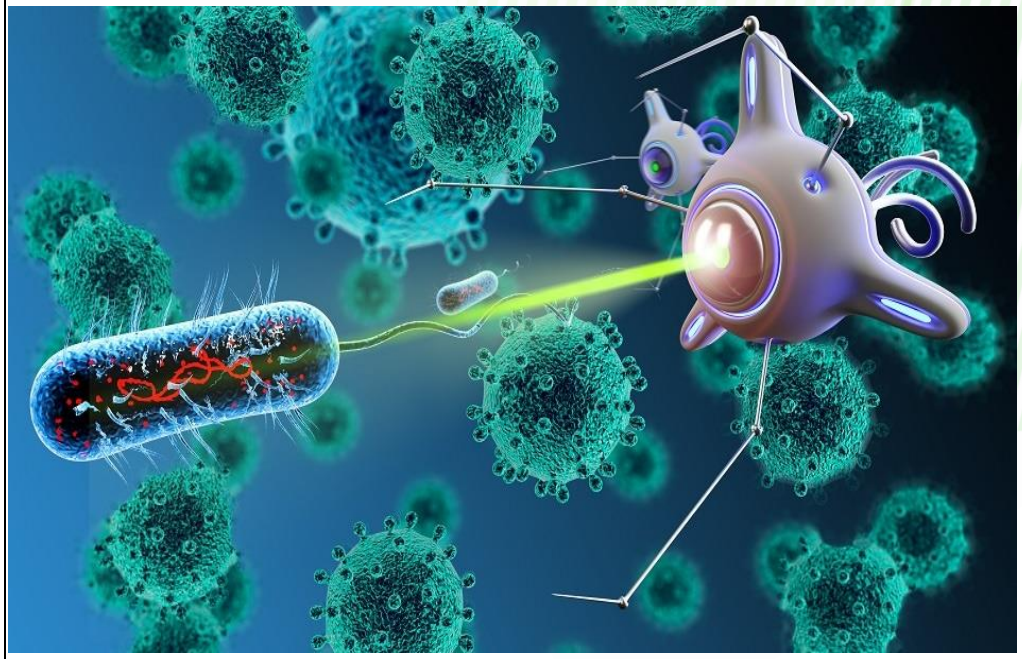
STORY CARD 5

The dangers of nanotechnology for human health

UK Council on Science and Technology Report (UK Council for Science and Technology) criticized the government for not funding more research on the toxicological, health and environmental effects of nanotechnology. Today's knowledge gap on the impact of nanoparticles on human health raises concerns - and "requires" immediate basic research. Nanoparticles could potentially invade organs and organs of the human body with adverse health effects. For example, nanomaterials such as metal oxides and carbon nanotubes could (theoretically) behave like quartz dust or asbestos particles and have similar destructive effects on the respiratory system. Studies have shown that the human body's defense mechanisms can treat nanoparticles such as microorganisms, but nanomaterials can and do bind together, forming fibers that are too large to be absorbed by macrophages. Nanoparticles contain a large proportion of metals, and have large active surfaces that could alter the toxicity of the particles and thus damage human cells.



The rapid growth of nanotechnology has led to exciting developments in gene therapies, targeted drug delivery systems, molecular imaging and implant devices. Most of these are based on techniques that handle nanoparticles so that they can bypass the human body's defense mechanisms, which may mean that less desirable nanoparticles could also penetrate cells or cross natural barriers. However, the United Kingdom Medicines Agency (MRHA) He recently argued that existing regulatory frameworks and trial security procedures are sufficient to cover the use of nanotechnologies in drugs and medical devices. Now, MRHA has now decided to stop participating in the Nanotechnology Standardization Committee of the British Standards Institute, a situation which the Institute describes as "very worrying". MRHA should immediately reconsider the development of standards for nanotechnology. The unknown and insufficiently researched effects of nanotechnology on health make it unclear whether or not certain conclusions can be drawn about their long-term safety.

Source: The Lancet. (2007). *The risks of nanotechnology for human health*. The Lancet, 369(9568), 1142. doi:10.1016/s0140-6736(07)60538-8. Photo: https://www.azonano.com/article.aspx?ArticleID=5113

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STORY CARD 6

Anxiety, Negative effects

- Magnetite nanoparticles (Fe3O4) have been widely used to absorb toxic ions, such as arsenite. However, free nanoparticles in natural waters could have a devastating effect on aquatic organisms.
- Recent studies on iron metal chemistry, however, have shown that ZVMs (zero-strength metals) have several disadvantages in their application. These include the formation of iron oxides on the surface, an increase in the pH of the solution, and a decrease in reactivity over time.
- Free-conducting polymer nanoparticles could end up in natural waters and have toxic effects on aquatic organisms. Indeed, it has been observed that nanoparticles have teratogenic effects on frog larvae.
- Molecules used in medical treatments, such as animal or human proteins, hormones, blood residues, and certain medications. Among these products, hormones and anticancer drugs are growing very fast for 10 or 20 years without paying much attention to their environmental impact. These substances end up in the water molecules and reach the rivers and, finally, the ocean.
- In rivers, sewage ends up in plants, where the concentration of these molecules can be high, these molecules interact with living organisms, modifying the natural distribution of sex and the balance of aquatic species, especially fish.

Source: Loukas G., Pananikolaou K. (2015) Use of nanotechnology methods in water purification and desalination. Thesis, TEI West. Of Greece, Photo: http://www.micro-nano.net/opportunities-challenges-of-nanomaterials-in-medicine/

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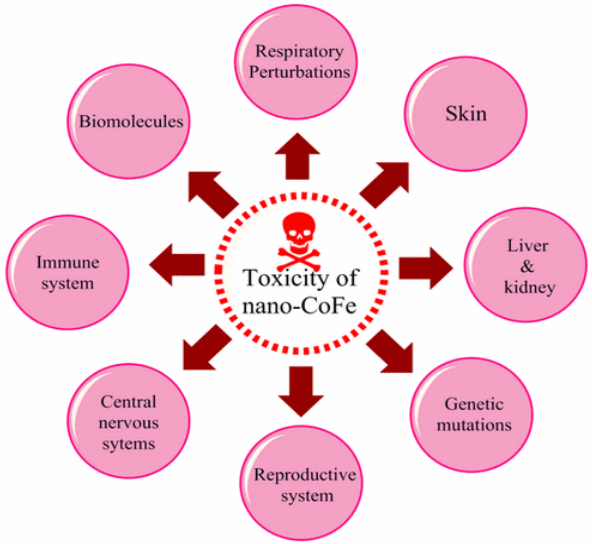
STORY CARD 7

Traps and Challenges in Nanotoxicology: The Circumcision of Corolla Ferrite Nanococci (CoFe2O4)



"Nanotechnology is developing rapidly and with many promises for a bright socio-economic future. Concerns and objections to the growing involvement of nano-technology (in all fields of applied sciences) make nanomaterials ubiquitous in 'everyday life. Nano-technology clearly helps us visualize the new mysterious horizons in nanotechnology (e.g. nanorobots), nano-electronics (even smaller chip), environmental restoration and nanotechnology. In all of these key issues, cortical enzyme nanoparticles (CoFe) (NPs) are excellent candidates for their amazingly controlled physicochemical and magnetic properties, as well as their easy-to-use synthesis methodsExtensive use of CoFe NPs, however, can result in CoFe's NPs easily penetrating the human body by ingestion, inhalation, aspiration, etc. When they enter the human body, they can cause conditions such as oxidative stress, cytotoxicity, genotoxicity, inflammation, developmental, metabolic and hormonal abnormalities.

Source: Ahmad, F., & Zhou, Y. (2017). *Pitfalls and Challenges in Nanotoxicology: A Case of Cobalt Ferrite ($CoFe_2O_4$) Nanocomposites*. Chemical Research in Toxicology, 30(2), 492–507. doi:10.1021/acs.chemrestox.6b00377 , http://bit.ly/2YdzlSF .

STORY CARD 8

Nanomaterials & Pharmacology

"In selective medicine, the selective transfer of drugs to tissues and organs, as well as the controlled release of drugs into cells for the most effective treatment of diseases, play a particularly important role. Drugs can be released into the human body either orally, through the respiratory system, or through implants. The main advantages of nanoparticles over other drug carriers are: (a) their small size, which helps them to overcome normal obstacles they encounter in the human body and enter its cells, (b) increased solubility. enhances their bioavailability, (c) their ability to be delivered to specific targets with controlled release from specific signals, which are usually based on temperature sensitivity or some magnetic property. Nanotransmitters can also be used to treat cancer as targeted drug delivery systems with reduced toxicity and side effects due to its ability to penetrate cancerous tumors. The stability of the internal and external distribution of nanoparticles in this biological microenvironment depends on their chemical nature, spatial orientation and size. However, some of the drugs or treatments that have been tested in the laboratory and show very good results in laboratory studies do not seem to have the same good results in clinical practice. This may be due to the degradation of the therapeutic substance before it reaches the predetermined target as well as the low solubility of the drug as it spreads to the human body. "

Source: IEP (2017) SUBJECT I: Plan for the preparation of Creative Work Indicative Indicative Example: Chemistry, 2nd Lyceum, http://bit.ly/2JLy8xV & *Alshahrani A., (2016), The Advantages of Nanotechnology in Medical Field , International Journal of Innovative Research in Electrical, Vol. 4, Issue 4, April 2016, DOI 10.17148/IJIREEICE.2016.4401 1, , ISSN 2321 – 2004, Photo: https://nanotechnology.alliedacademies.com/*

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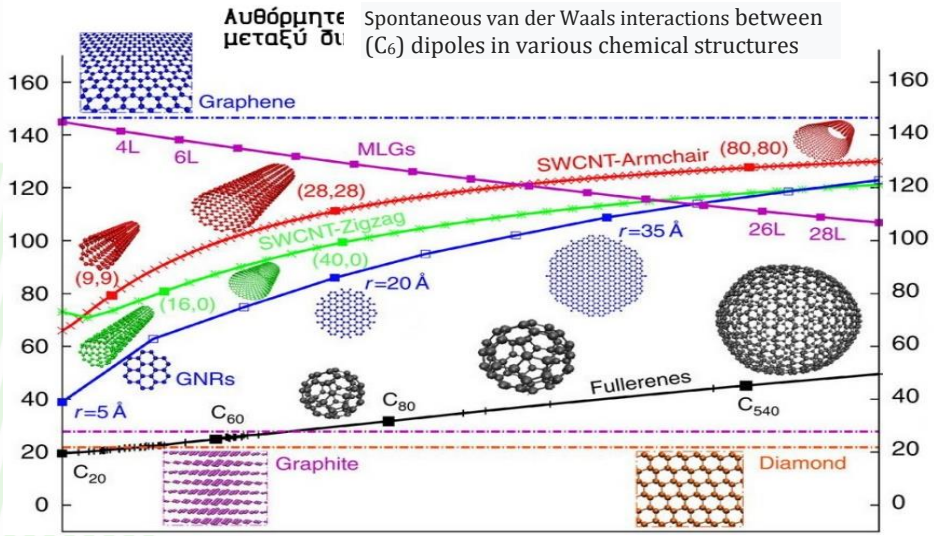
STORY CARD 9

Nanomaterials & Live Organisms

"Nanotechnology companies, in order to turn nanoparticles into useful and marketable products, study living organisms in their natural environment, as these organisms have specialized organic nanoscale structures. The best and most well-known example of a self-cleaning surface is the so-called **lotus effect.** The lotus phenomenon owes its name to the way the leaves of the lotus flower are cleaned. It was discovered by botanists Wilhelm Barthlott and Christoph Neinhuis from the University of Bonn in Germany. The lotus flowers are covered with tiny hydrophobic particles. During the contact of water with these particles, the water does not stay in the leaves but flows, taking with it at the same time every dirtAlso, beetles, flies, spiders, gecko lizards revealed their secrets at the Max-Planck Institute of Mining in Stuttgart. They attach to the surfaces where they grow with the help of hairs δεσμοί Van der Waals. The heavier the animal, the thinner and more numerous the hairs. Observing the legs of a gecko lizard under a simple microscope, hundreds of folds can be seen. Observing even closer, with a more powerful microscope, it is found that, in each fold, there are millions of bundles, consisting of very small hairs, so small that they can only be calculated on the nanoscale. Finally, the Fraunhofer IFAM Institute in Bremen is conducting research on modified mussel glues, in order to be able to weld very thin porcelain capable of withstanding washing in a dishwasher. The reason is that when a mussel clings to a rock, it opens its lockers and pushes its foot towards the rock, bends its foot to form a suction cup and, through tiny conduits, secretes adhesive pellets into the vacuum pit. There, the beads are broken and release strong adhesive, which immediately forms small foam "cushions". In this way, the mussel manages to be shaken by the wave due to the absorption of vibrations by the foam. "



Spontaneous van der Waals interactions between (C_6) dipoles in various chemical structures

Source: IEP (2017) SUBJECT I: Plan for the preparation of Creative Work Indicative Indicative Example: Chemistry, 2nd Lyceum, http://bit.ly/2JLy8xV (Diagram from Gobre V.V. & Tkatchenko A., (2013), *Scaling laws for van der Waals interactions in nanostructured materials*, Nature Communications volume 4, Article number: 2341)

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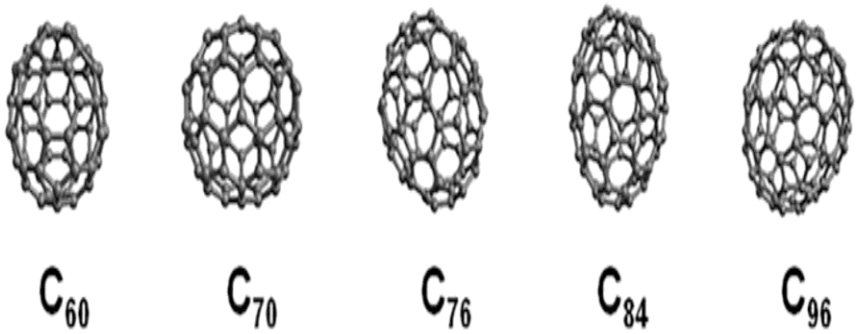
STORY CARD 10

Fullerenes



These are spheres with 60, 70 or more carbon atoms connected to each other in 5-membered and 6-membered rings in a total arrangement of regular polyhedra. The full name of the C-60 is buckminsterfullerene (often referred to as *bucky-ball*) in honor of the American architect Richard Buckminster Fuller. **Fullerenium has applications in cosmetics and pharmaceuticals, lubricants for machine parts, as well as electronics.** The most stable of these molecules was found to consist of 60 carbon atoms. Of particular interest are intrahepatic fullerenes in which individuals or molecules are incorporated, such as metal-fullerenes (complex nanoparticles), and water-soluble fullerenes that carry polar groups on their outer surface that reduce their hydrophobic character**.** More specifically, the intrahepatic fullerenes and their spherical structure allow the entrapment of atoms, molecules or ions into their inner cavity. Symbolized as **M@C60.** The symbol indicates that the person listed before C60 is located inside. The integration mechanism is not known. The literature has reported the preparation of intrahepatic complexes of fullerenes with ... Lanthanum (La), Ettrio (Y), Scandio (Sc), Selenium (Ce), Neodymium (Nd), Samario (Sm), European (Eu), Gadolinium (Gd), Tyrbio (Tb), Dysprosio (Dy), Holmio (Ho), and Irvio (Er). Also, inside the fullerenes, noble gas atoms (He, Ne, Ar, Kr, Xe) have been trapped under conditions of high pressure and temperature. Fullerenine C60 can act as a hydrogen accumulator - so that H can then be used as fuel, lead a molecule of organic molecule to the desired position (e.g. in a protein), act as quantum dots on supercomputer processors or controls fiber optic communications. Also in superconductivity, for example, a fuller mixed with potassium (K) or rubidium (Rb) became a superconductor at 28 - 29K. Scientists estimate that they will pave the way for individual watches of a new "generation", i.e. devices for measuring time with extremely high measurement accuracy that will not exceed the size of microchips. Therefore, unlike today's personal watches, they will be able to be integrated into mobile phones, for example, to make GPS function much more accurate.

Source: Alves et al. (2014) *Nanotoxicology – Materials*, ISBN 978-1-4614-8993-1, DOI 10.1007/978-1-4614-8993-1, Springer & Vougioukalakis C, Materials Chemistry (Organic Materials), Department of Chemistry Organic Chemistry Laboratory, EKPA , http://bit.ly/2YrhVC1 & IEP (2017) SUBJECT I: Plan for the preparation of the creation of Creative Work Indicative Example: Chemistry, 2nd Lyceum, http://bit.ly/2JLy8xV, & IEP (2017) SUBJECT I: Plan for the preparation of a Creative Work Indicative Example: Chemistry, 2nd Lyceum, http://bit.ly/2JLy8xV & Jorio A. (eds.), (2016), Bioengineering Applications of Carbon Nanostructures, ISBN 978-3-319-25907-9, DOI 10.1007/978-3-319-25907-9, Springer International Publishing.

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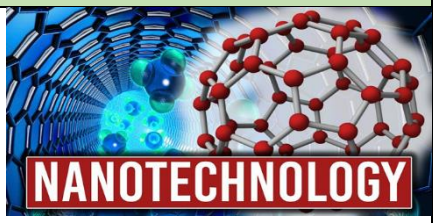
STORY CARD 11

Nanotechnology and application



After more than 20 years of research in nanoscience and more than 15 years of focused research in nanotechnology, the applications of the latter offer in expected and unexpected ways its promise to benefit society. Nanotechnology contributes to the improvement, even revolution, of many fields of technology and industry: e.g. information technology, home security, medicine, transport, energy, food safety and environmental science. Below is a sampling of the rapidly growing list of nanotechnology benefits and applications.

Daily Materials and Procedures - Many of the benefits of nanotechnology depend on the fact that it is possible to adapt material structures to extremely small scales to achieve specific properties, thus significantly expanding the materials science toolkit. Using nanotechnology, materials can more effectively become stronger, lighter, more durable, more reactive, or better conductors, among many other features. Many commercial products are on the market and are used daily and are based on nanoscale materials and processes.

- **Electronics and IT Applications** - Nanotechnology has contributed to significant advances in computing and electronics, leading to faster, smaller and more portable systems that can handle and store ever-increasing amounts of information.
- **Medical and healthcare applications** - Nanotechnology is already expanding the medical tools, knowledge and therapies currently available to physicians. Nanomedicine, the application of nanotechnology in medicine, is based on the natural scale of biological phenomena to produce precise solutions for the prevention, diagnosis and treatment of diseases.
- **Energy Applications** - Nanotechnology finds application in traditional energy sources and significantly improves alternative energy approaches to meet the growing energy requirements worldwide.
- **Environmental remediation** - In addition to the ways in which nanotechnology can help improve energy efficiency, there are also many ways that can help identify and clean up environmental pollutants.
- **Future benefits of transport** - Nanotechnology offers the promise of developing multifunctional materials that will contribute to the construction and maintenance of lighter, safer, smarter and more efficient vehicles, aircraft, spacecraft and ships. (Source: https://www.nano.gov/you/nanotechnology-benefits)

At the same time, it should be borne in mind that although the benefits of using nanotechnologies are many, these technologies, due to their high cost, are mainly controlled by developed countries and multinational companies. This has resulted (at least for now) in making technologies inaccessible to the general public, further consolidating the divide between residents of developed and developing countries.

Sources : Sheetza T, Vidal J, Pearson TD, Lozano K. Nanotechnology: Awareness and societal concerns. Technology in Society, 2005, 27: 329–345 and Gammel S. Nano-Ethics. Basic Ethical Concepts. The Ethics Porfolio. Technical University Darmstadt for NanoCap. 2009.

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QUESTION CARD 1	QUESTION CARD 2	QUESTION CARD 3	QUESTION CARD 4
Is there really a large presence of nanomaterials in 'everyday life' and what effect can this have on the health of the population?	What do you consider to be the most important applications of nanomaterials?	What effect can the need for nanomaterials have on the process and the purchase of the 'raw materials' required?	Should we treat nanotoxicity as a new class of toxicity, of which little is known, giving special weight to vulnerable populations (e.g. children) whose bodies are more vulnerable than adults?

QUESTION CARD 5	QUESTION CARD 6	QUESTION CARD 7	QUESTION CARD 8
How likely is it that the (uncontrolled) release of nanoparticles into the atmosphere and what effect can this have on public health? Can there be countermeasures to nano-pollution using nanomaterials?	Are there biological effects of nanomaterials on both animals and plants?	What are the positive uses of nanotechnology?	Does medicine have anything to do with nanomaterials?

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QUESTION CARD 9	QUESTION CARD 10
How old is nanotechnology?	

Nanomaterial type	BSI (United Kingdom 2007)	IFA (Germany 2009) & SER (Netherlands 2012)	SWA (Australia 2012)	NIOSH USA 2013)
Fibers	0.01 fibers/cm^3	0.01 fibers/cm^3	0.1 fibers/cm^3	0.007 mg/m^3
Granular	20 000 particl./ cm^3	40 000 particl./cm3	0.3 mg/m^3	0,003 mg/m^3

Referring to the table above, do you see differences in the "tolerable" or "permissible" values of nanoparticles in the various organisms? Where do you think this is due to and what effect can this have on our health?

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Prepare the arguments for the discussion. A group of students prepares arguments that support one view, or another has contradictory arguments. Use the suggested figure.

ARGUMENT N^{O} 1.

Argument (s)	Foreseen rebuttals from the other team	Answers to rebuttals

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ARGUMENT N^{O} 2.

Argument(s)	Foreseen rebuttals from the other group	Answers to rebuttals

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ARGUMENT N^{O} 3.

Argument (s)	Foreseen rebuttals from the other group	Answers to rebuttals

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Responsible for the educational material: Dimitrios I. Sotiropoulos

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Nanotechnology Health and Environment

Dimitrios I. Sotiropoulos, Member of H.I.R.C.S.,
Physicist, M.E.d. in Science Teaching
Ph.D. in Education in Science and Digital Technology

6, February 2020

Online Webinar

Institute of Geophysics
Polish Academy of Sciences

CENTER FOR THE PROMOTION OF SCIENCE

IRESE

ENERGIA AVASTUSKESKUS
ENERGY DISCOVERY CENTRE

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Initiation

https://www.youtube.com/watch?v=CjpXj2BqJBY

In today's online seminar/webinar

- You will learn the meaning of the nanoscale and
- the materials that have been created on this scale, which offer solutions and have advantages in their various fields of application (medicine, pharmacology, industry, cosmetics, ...).
- At the same time, you will recognize the contribution of the development of these materials to the economy and
- you will approach the potential risks to human health by (uncontrollably) dispersing them into the environment.
- You will learn what the European Union is doing to control their uncontrolled use.

4

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Theoretical Introduction

to Nanotechnology

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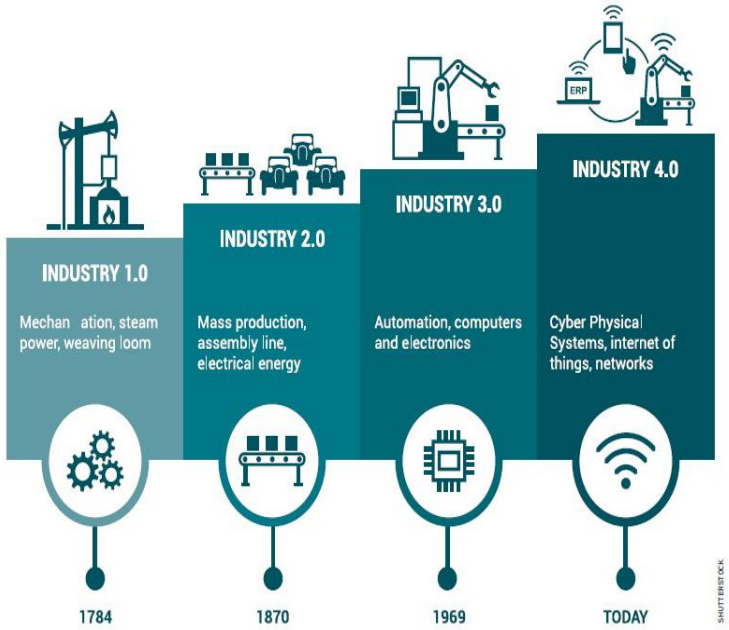
4th Industrial Revolution

The 4th Industrial Revolution (4BE / 4IR) has already begun. The countries that seek their evolution, as societies, participate in it by all means and in every way. Students, professors, universities, institutes, companies, institutions and politicians actively participate and contribute with their (corresponding) role to it.



The main technological dimensions, related to the 4th Industrial Revolution, are: Information Technology, Artificial Intelligence, Photonics, Nanotechnology, Biotechnology and Robotics.

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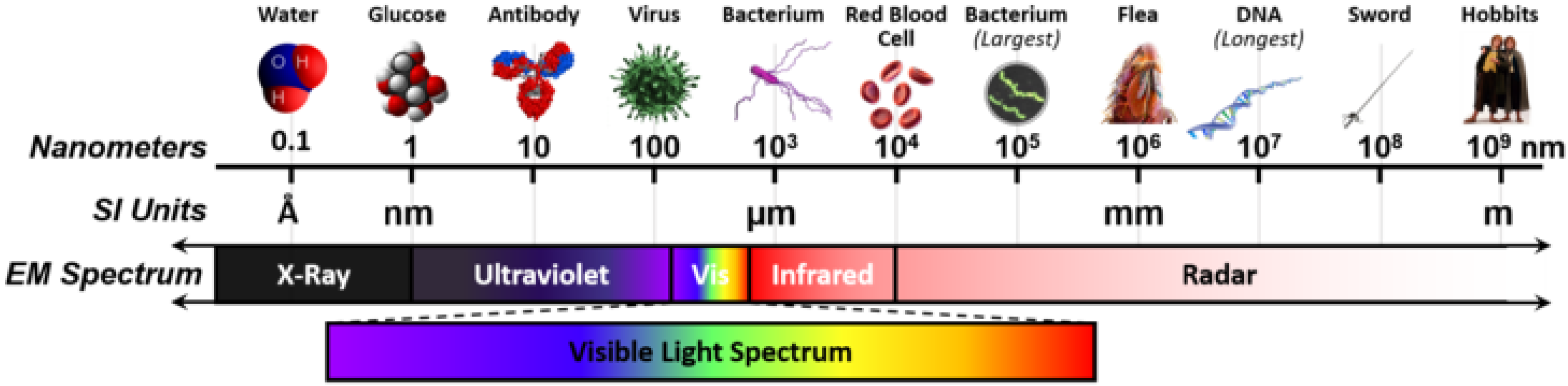
4th Industrial Revolution

Looking ahead with a vision and with the aim of European countries active participation in the global educational process, it is advisable for the students of the modern European school to be informed and to deal, in essence, with nanotechnology, which is one of the most important dimensions of the 4th industrial revolution.

Nano size ..how small is it?

- https://kapwi.ng/c/lgPpEadq



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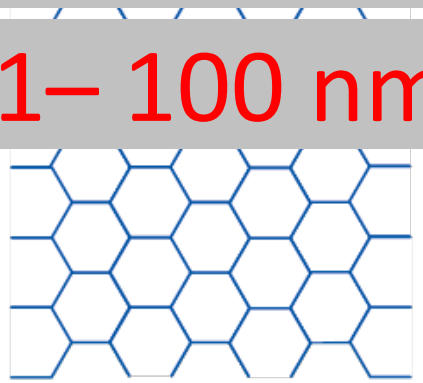
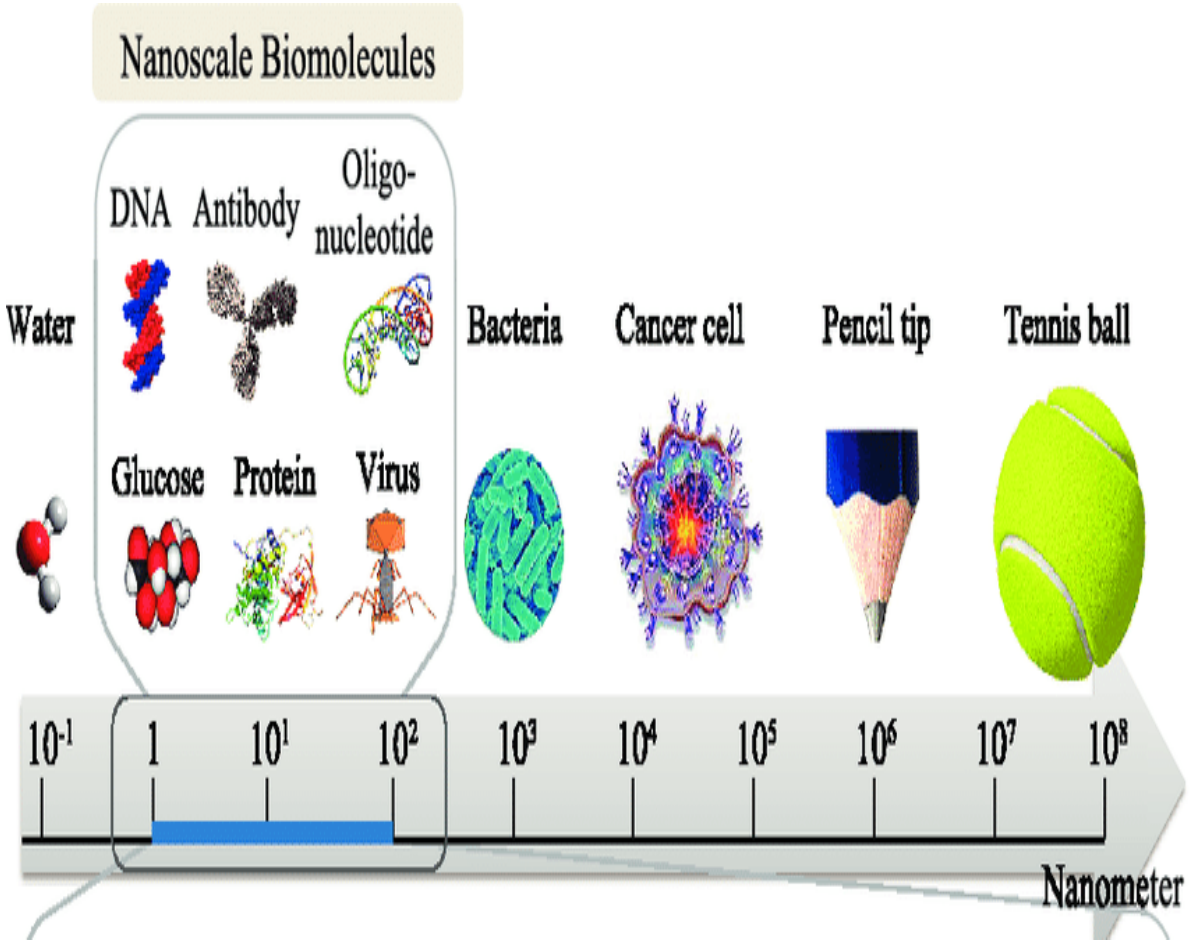
Nanomaterials

1– 100 nm



For example:

- The DNA molecule is a material of the nanoscale (1-2 nanometers in diameter), as are subcellular supermolecular complexes, such as ribosomes (20 nanometers). The same goes for viruses (30-100 nanometers) and prions (4-10 nanometers).
- The bacteria (germs) belong to the microclimate, as the dimensions of the microbes range from 200 and 300 nanometers (mycoplasmas) to 2-500 micrometers (E.coli = 2 micrometers and the giant bacterium Thiomargarita = 500-600 micrometers).



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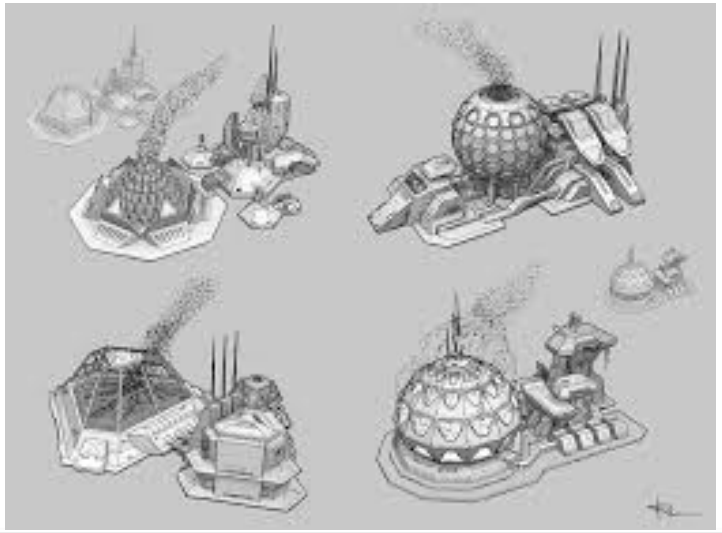
"I want to build a billion tiny factories, where one will be a model for the other, which will be put together at the same time. The principles of Physics, based on my estimations, do not contradict the possibility of handling material objects, person-to-person. This concept is not an attempt to violate the laws of nature. It is something that can happen and the reason why this has not yet happened in practice is that we are too big for that."

Richard Feynman, excerpt from his lecture series
on Nanotechnology, in 1959,
entitled''There's Plenty of Room at the Bottom''



https://transhumanistgr.wixsite.com/society/blog/η-μοριακή-νανοτεχνολογία-και-το-μοριακό-μέλλον-της-ανθρωπότητας

Nanotechnology

Nanotechnology is the study and technological creation of very small objects (located in the order of magnitude of nanometers / nm), which are applied in many fields, such as biochemistry, materials science, pharmacology, medicine and elsewhere.

The main activities of nanotechnology include the design and manufacture of nanomaterials at the level of the molecule and/or of the atom, as the case may be, as well as the various applications of these materials in industry and everyday life.

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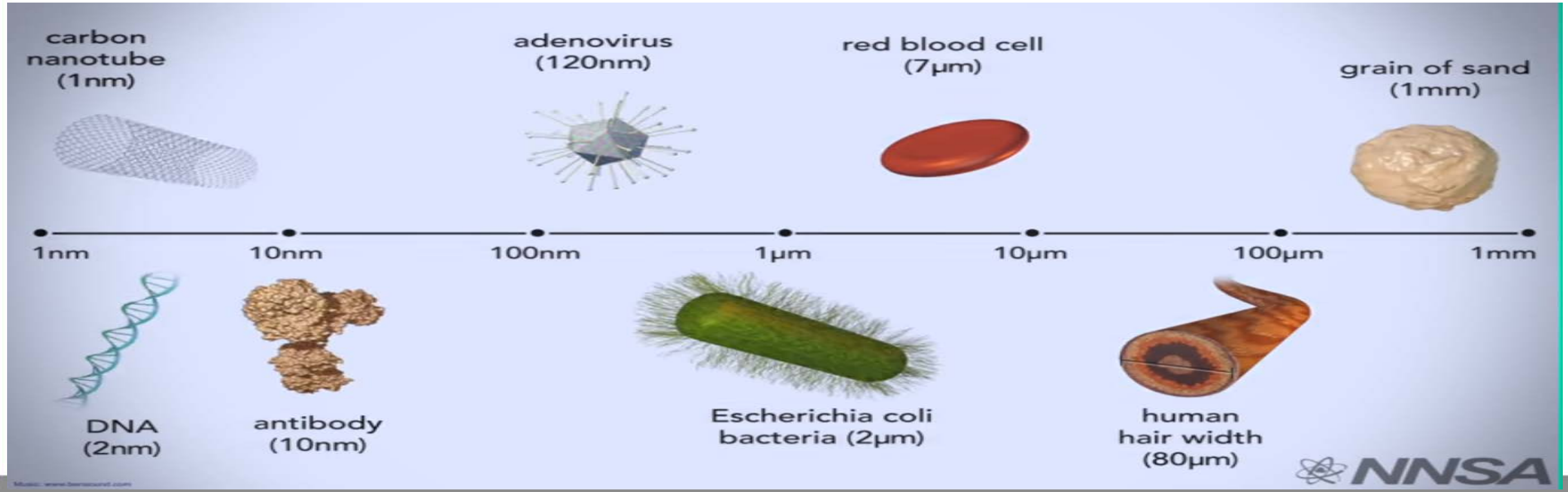
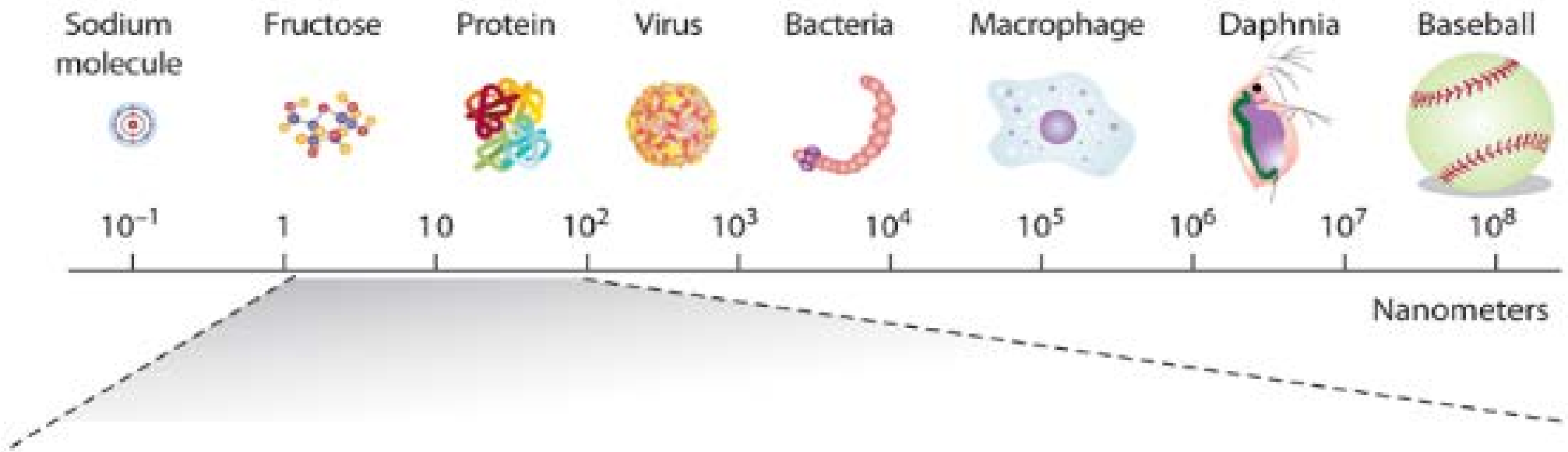
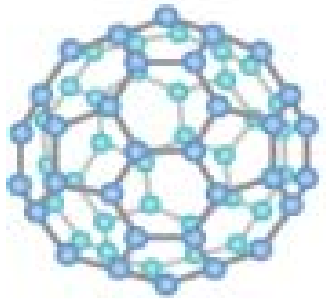
Let's look at the nanoscale

https://www.youtube.com/watch?v=sqv5ESP20tw

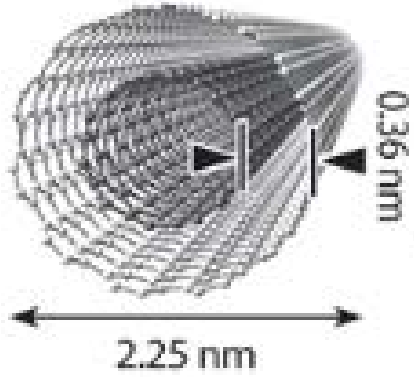


Nanoscale materials

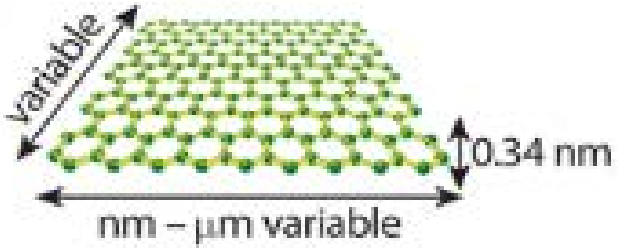




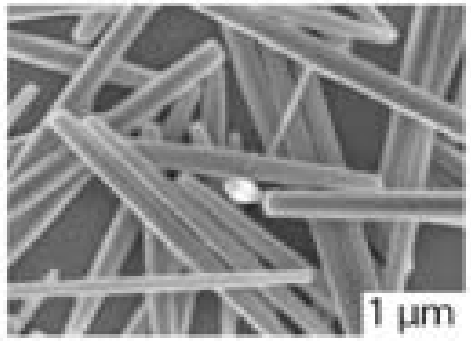
Bucky-ball



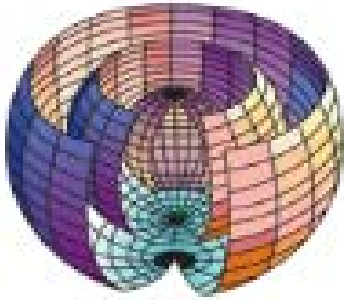
Carbon nanotube



Graphene



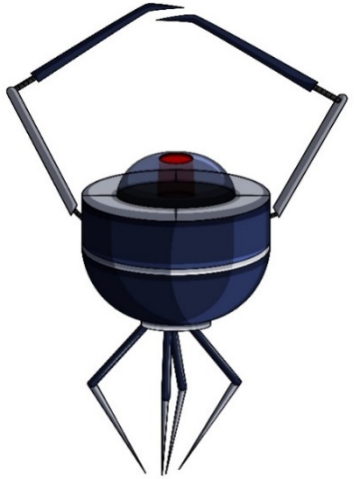
ZnO nanorods

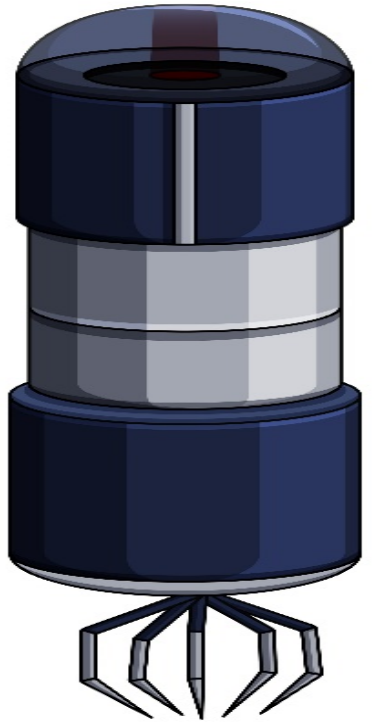


Nano-onion

Nano - Materials

- 1. What is nanotechnology?
- https://www.youtube.com/watch?v=dQhhcgn8YZo
- 2. How nanotechnology can change your life?
- https://www.youtube.com/watch?v=IGjCOJqINPA





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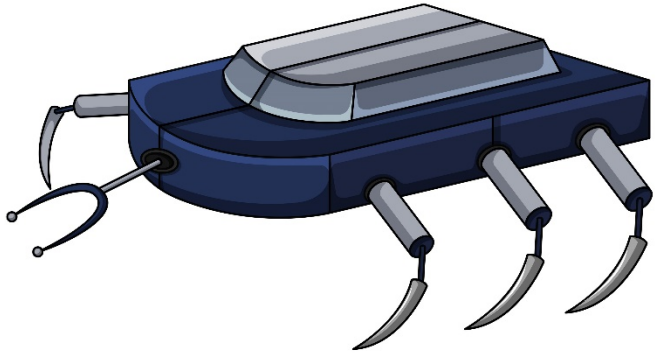
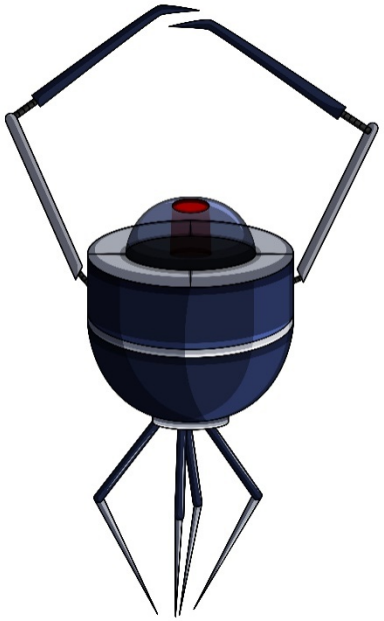
Nanomaterials

Nanomaterials Database





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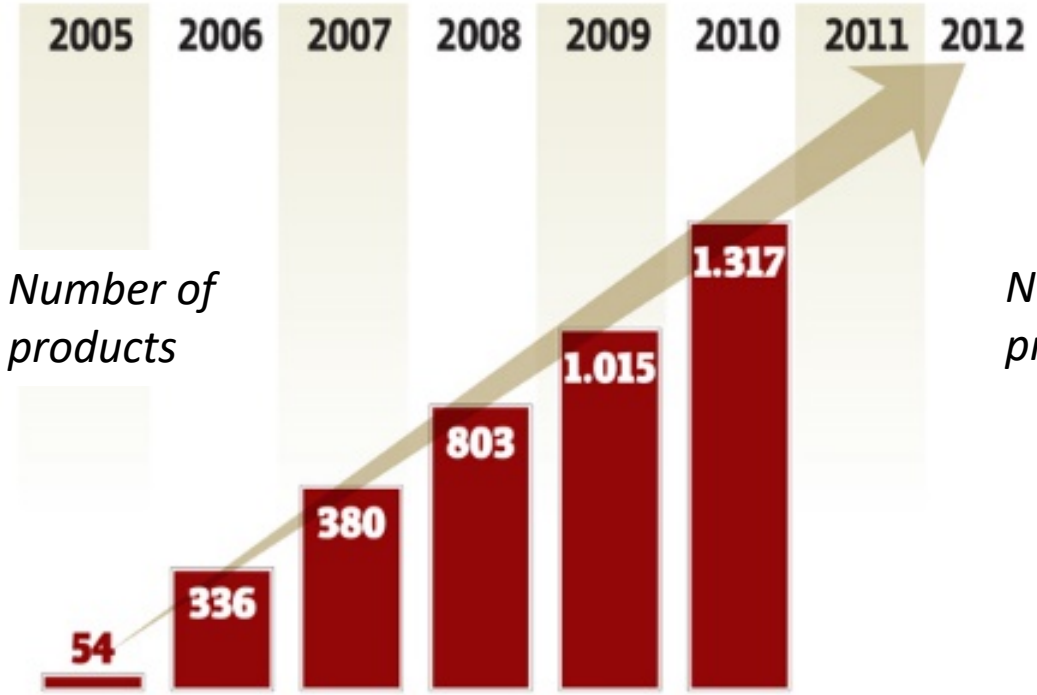
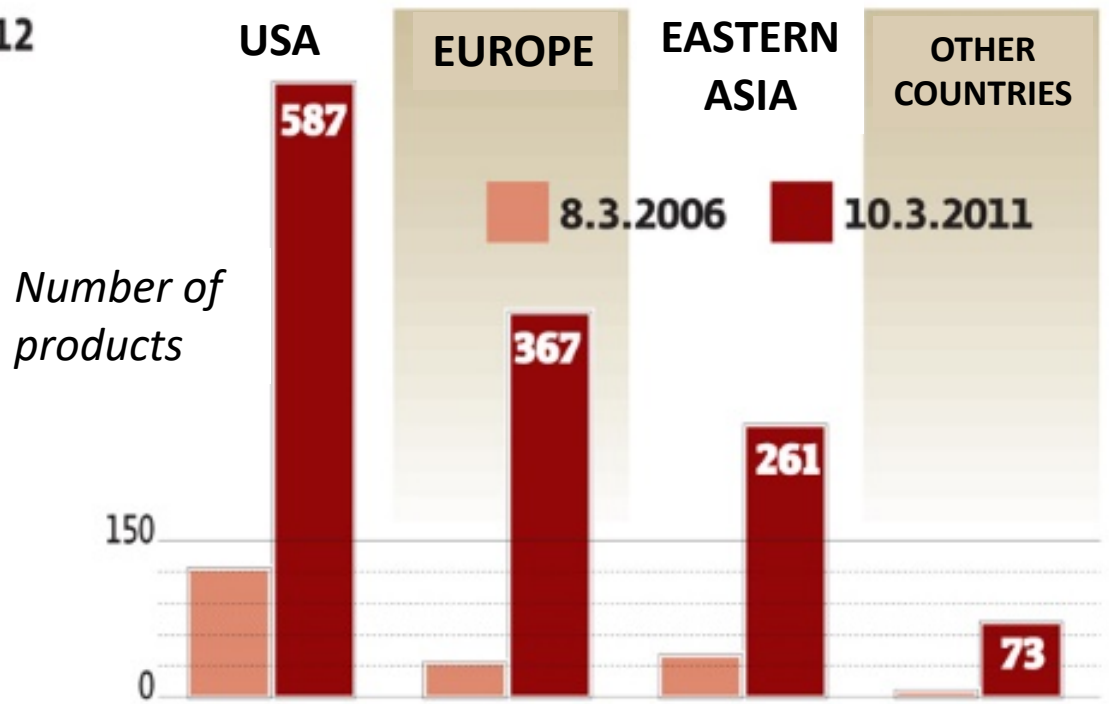
Nanoparticle products are growing exponentially



USA and Europe on top of nanoparticle products



Source: The Project on Emerging Nanotechnologies (http://www.nanotechproject.org/)

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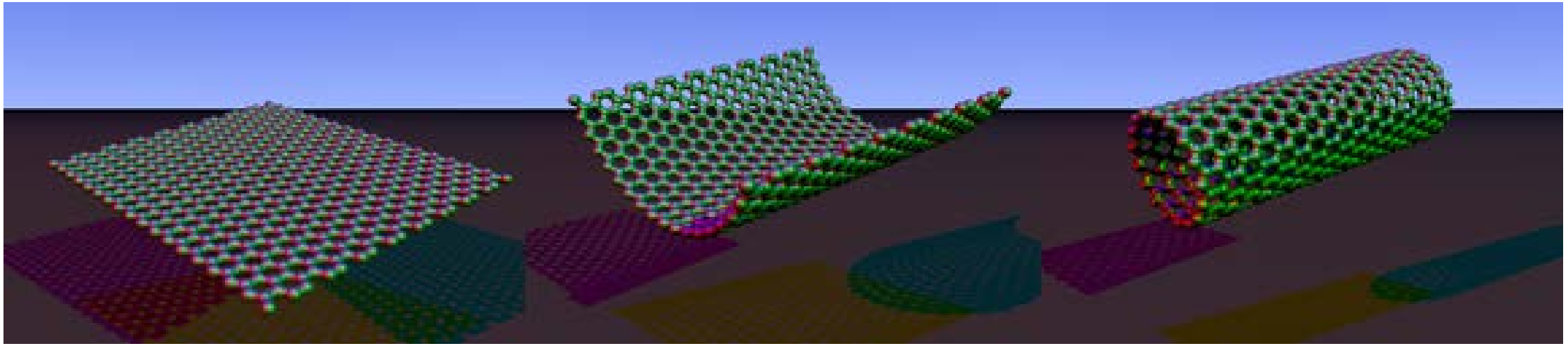
- **Carbon nanotubes**

The applications of carbon nanotubes are numerous.

Imagine a carbon pipe as a graphene mesh (carbon atoms), which wraps and creates a cylindrical surface.



https://nucleus2012.wordpress.com/2015/05/22/οι-τρομακτικές-δυνατότητες-της-νανοτ/

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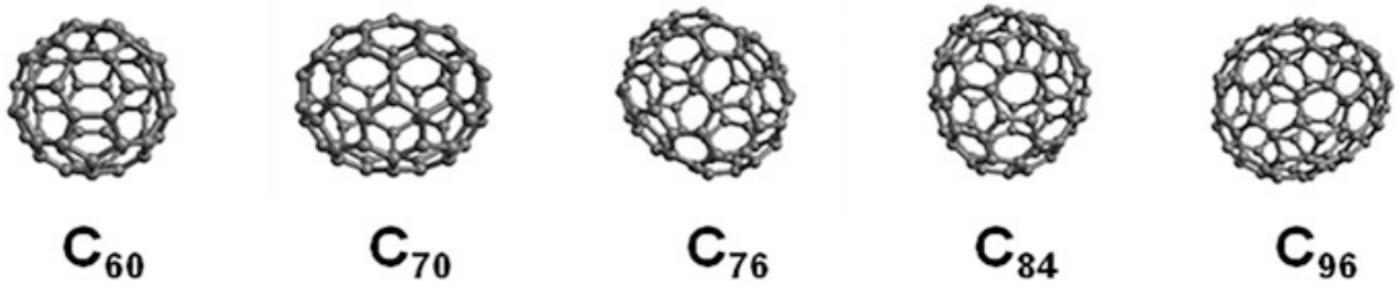
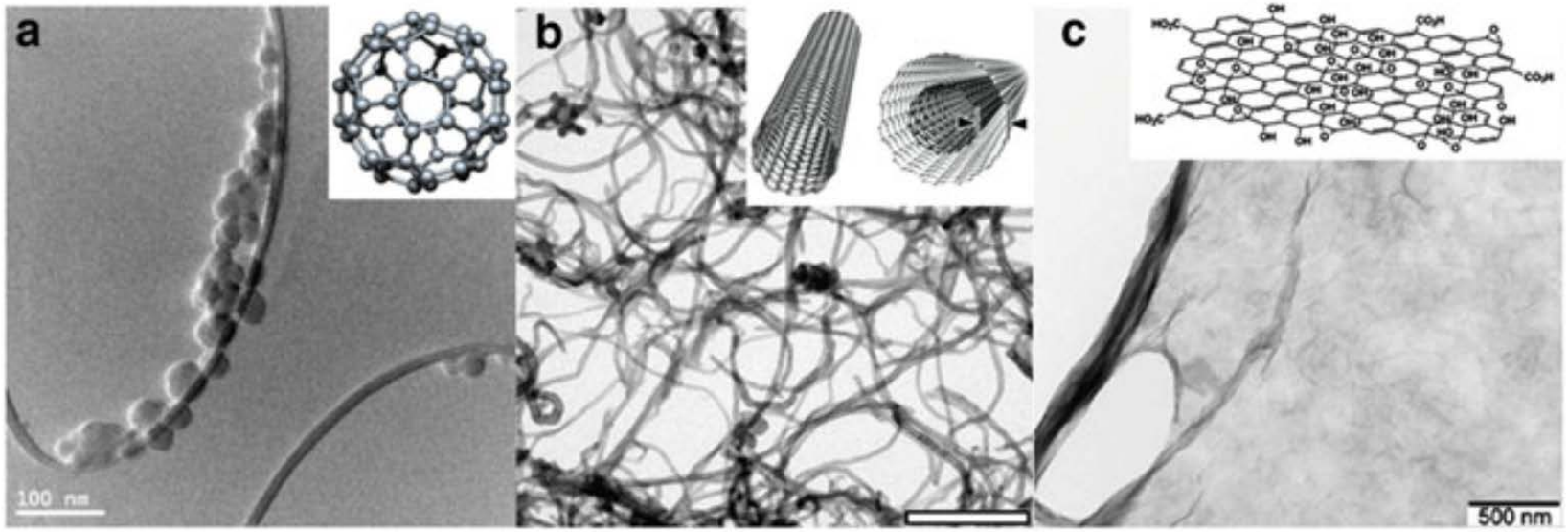
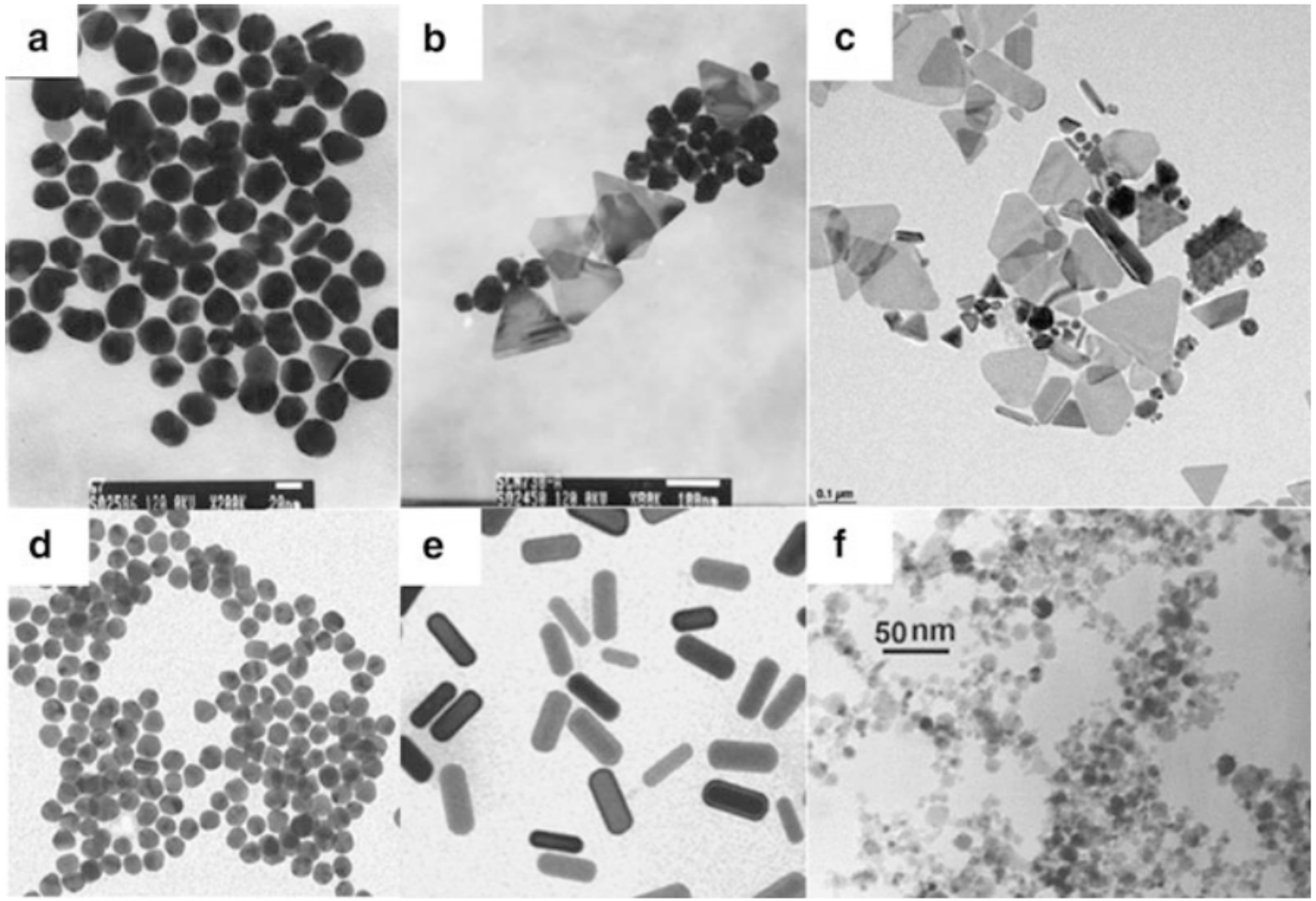
- **Fullerenia**





Pictures from...
a) fullerenes C-60
b) multi-structured carbon nanotubes
c) single layer of graphene oxide

Alves et al 2019:6



Pictures from...

a) spherical silver nanoparticles (Ag)

b) Ag nanoparticles (various shapes)

c) triangular and quadrilateral nano-mats Ag

d) global gold nanoparticles (Au)

e) gold nanorods (Au)

f) spherical nanoparticles TiO2

Alves et al 2019:13

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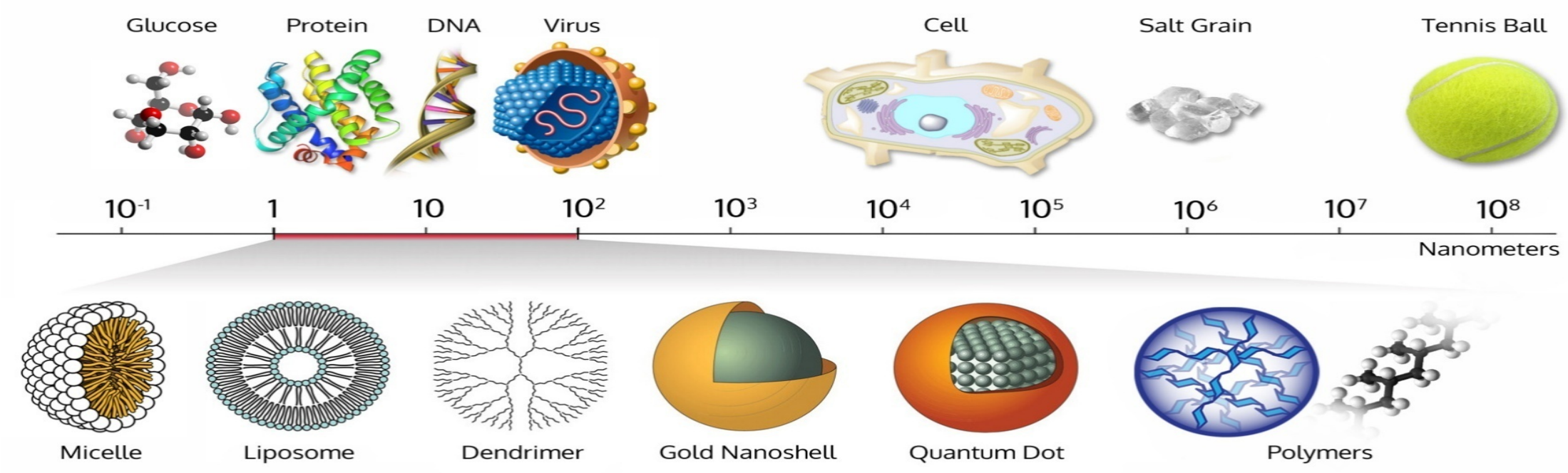
✓ Thanks to carbon nanotubes, it is possible to create lithium-ion batteries (the ingredients are simply ‘sprayed’ on a surface!)



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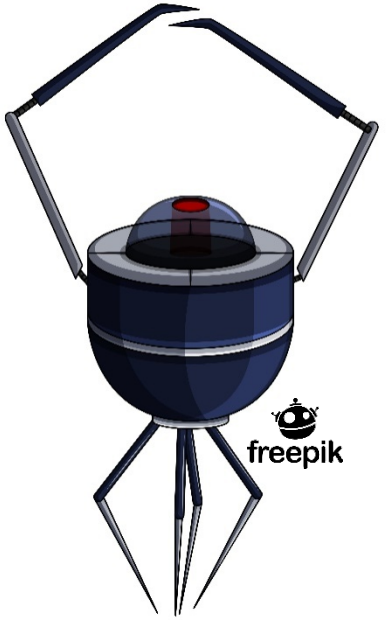
- ✓**Carbon nanotubes can be used to transport substances to specific cells in the body but also as sensors of substances inside our body. They can carry substances that will only kill cancer cells or speed up the process of repairing broken bones. They can also detect at an early stage e.g. proteins that indicate a serious illness, such as cancer.**



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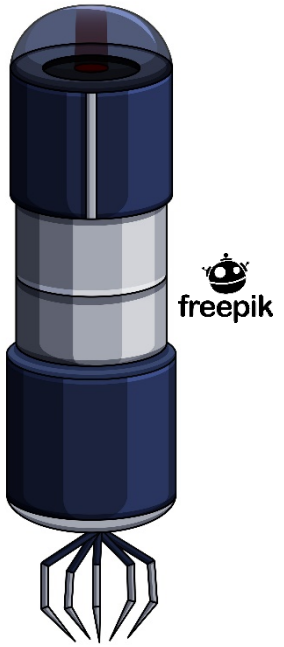
✓Carbon nanotubes can help to protect the environment, as materials can be created that will absorb and trap oil spills. In addition, they can be used in so-called reverse osmosis membranes, creating relatively inexpensive and efficient water purifiers that provide a solution to the problem faced by many poor countries.



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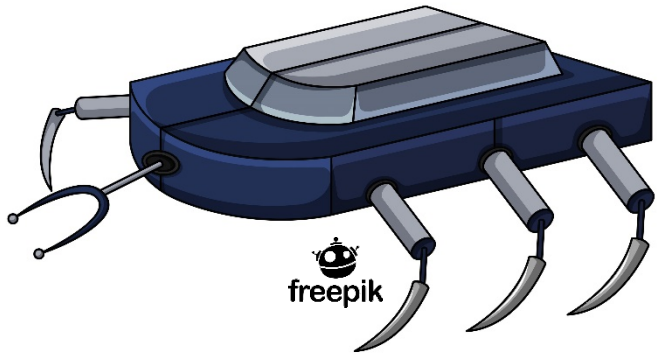
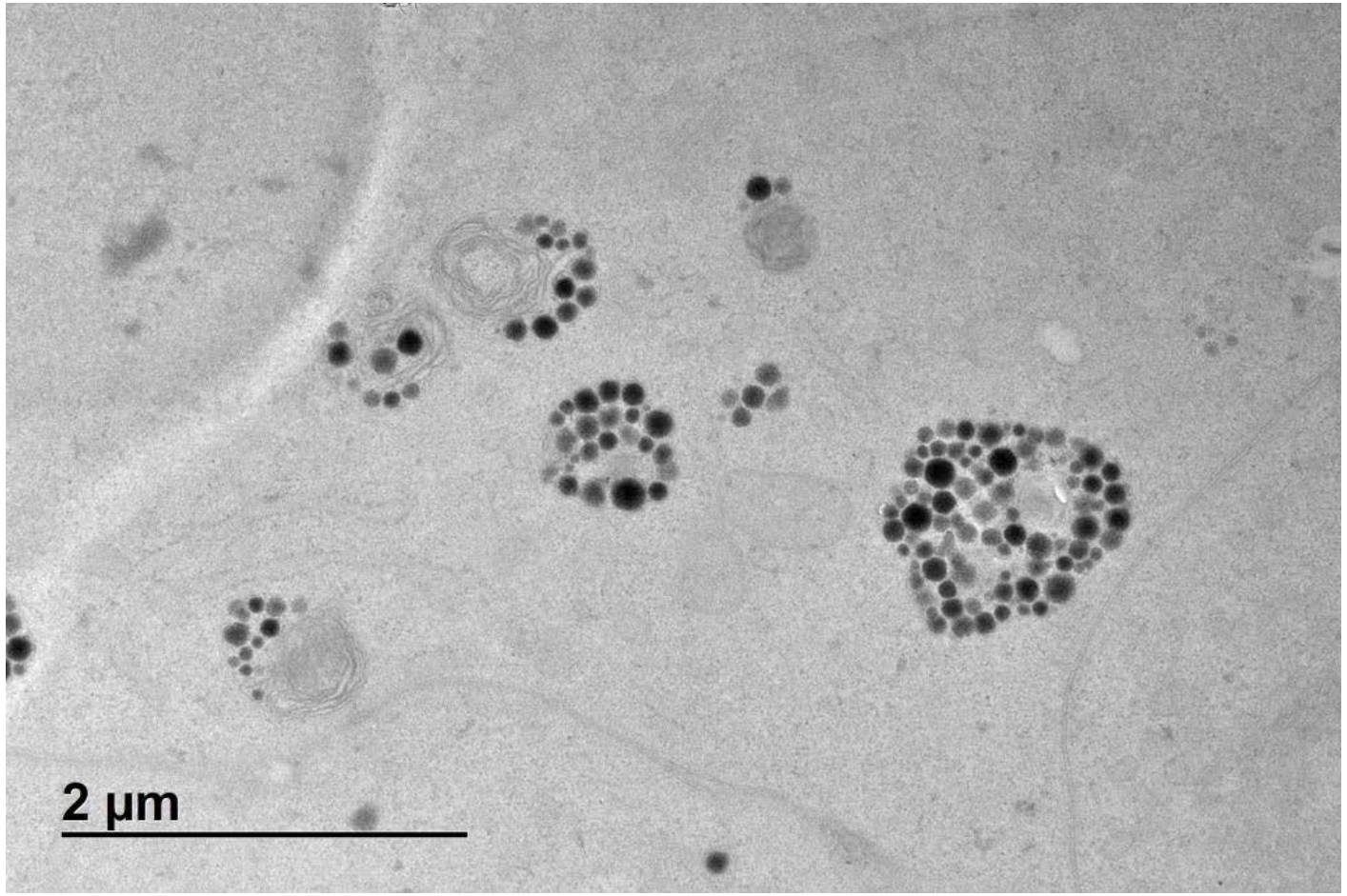
✓ In addition, it is possible to make materials with nickel nanoparticles, which can be "self-healing" if, for example, they are somehow cut. Also, the same particles can - due to changes in the structure of the material, when pressure is exerted on it (and then return it to its original state) - give the robots a feeling like touch!

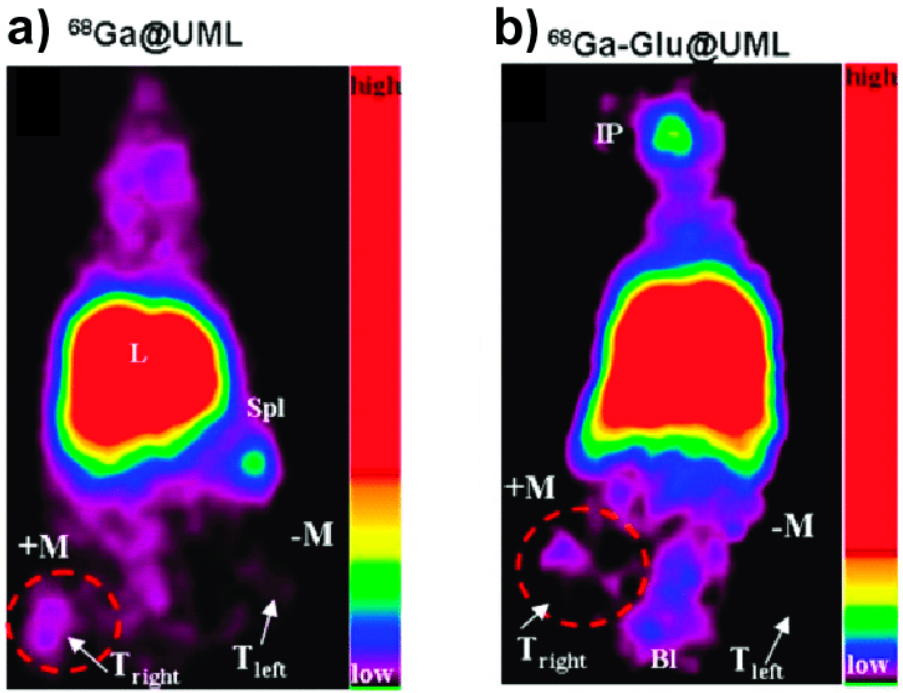


Medical Applications

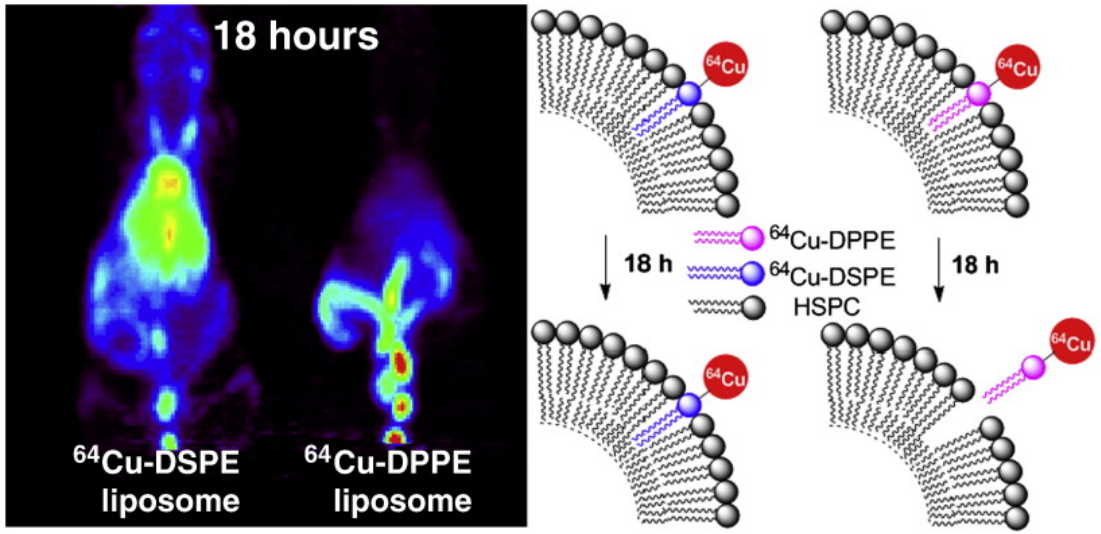


The photo shows carbon nanoparticles (C) transported by glucose molecules and offering great potential for future use in the treatment and diagnosis of cancer.

Medical Applications

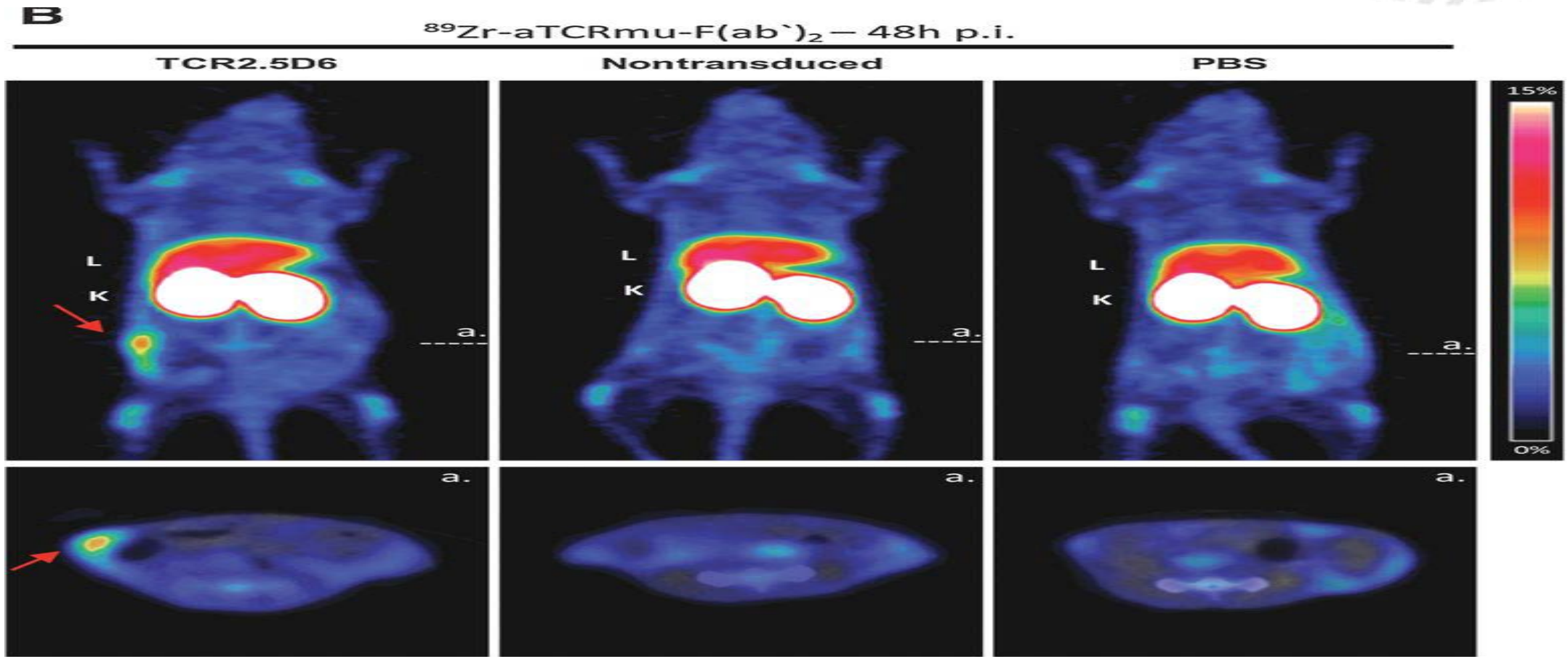


Gallium nanoparticles(Ga)



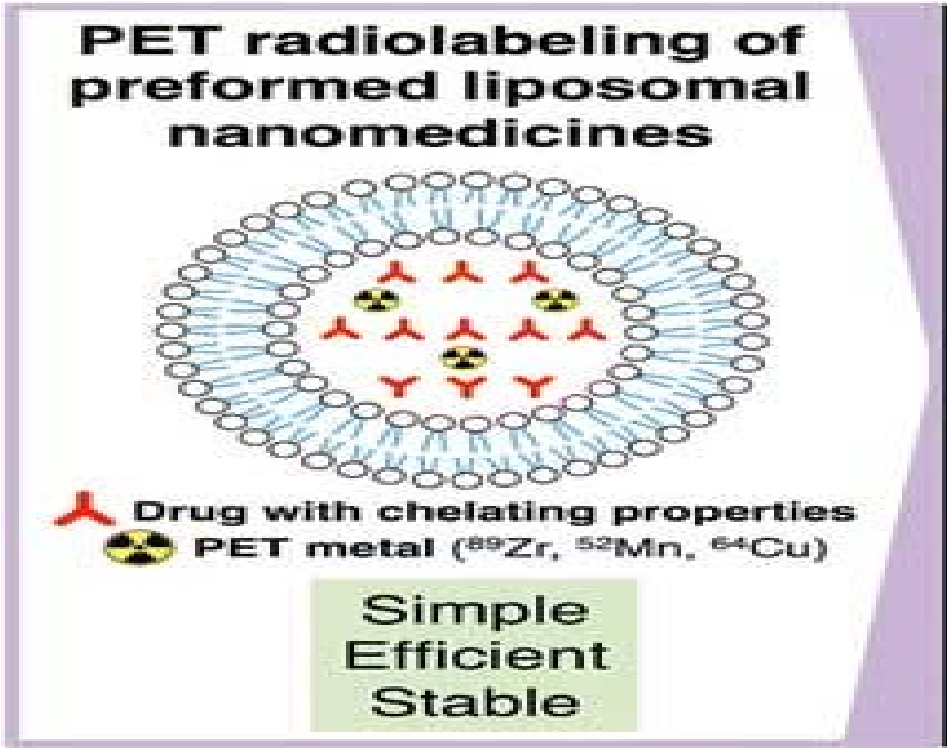
Copper nanoparticles(Cu)

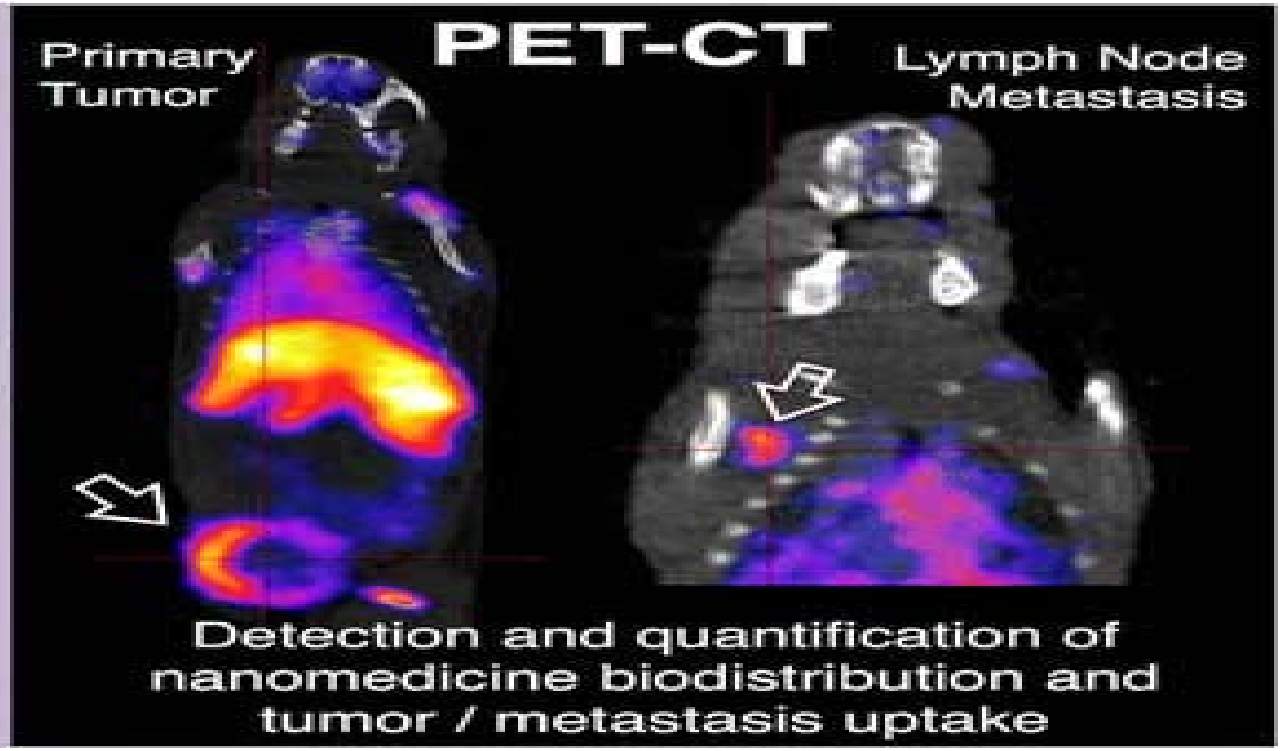
Medical Applications– PET scanning



Zirconium nanoparticles(Zi)

Medical Applications– PET scanning





Zirconium nanoparticles(Zi)

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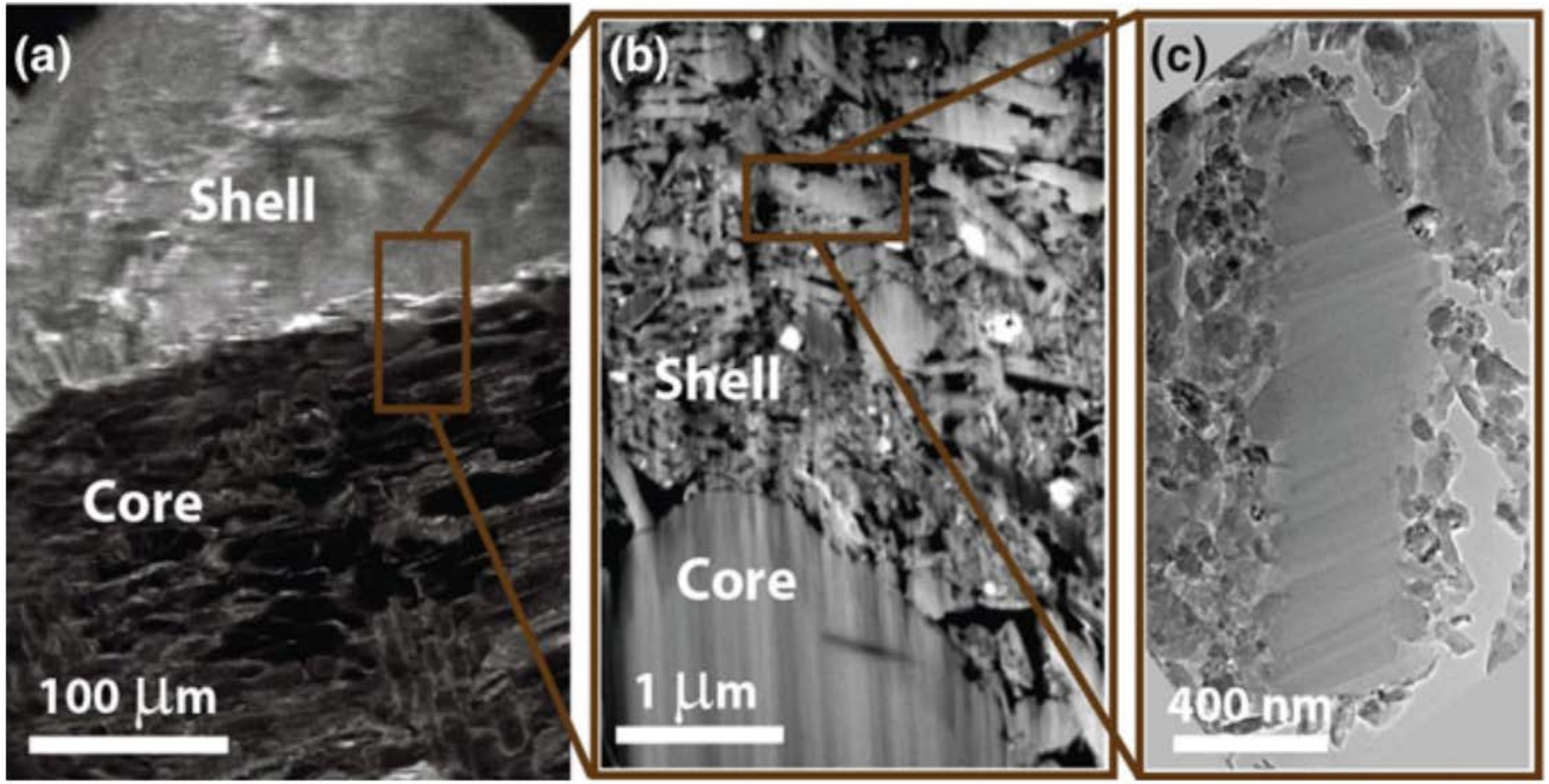
Medical Applications -

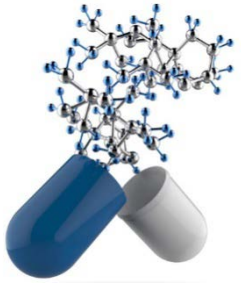


The photo shows the interface between the graphic core and the porous nano-surface.

Jorio 2016:89

Biomedical Applications

Nanoparticles are used in the diagnosis of diseases, in the 'delivery' of drugs, in the gene therapy of cancer, in lung diseases and in the prevention of other infections.



(Singh 2017)

Food production

Nanomaterials, mainly metal-based and carbon-based nanomaterials, have been used for their absorption, displacement, and crop aggregation. The positive effects included increased vegetation rate, longer root and shoot length and more plant biomass in many crops - e.g. of corn, wheat, rye, soybeans, tomatoes.

(Singh 2017)

Safety

Nanotechnology increases the ability of tiny recording devices, which would be almost undetectable. Nanotechnology applications in gun design are a nightmarish scenario. For example, the "smart sphere", that is, an electronic sphere that could be controlled and targeted with great precision.

(Edwards @ chron.com)

Materials - Engineering

Nanotechnology has already 'offered' new ones - such as nanotubes and aerosols - which consist of very light but strong structures, with remarkable insulating properties. Also, robots with a length of only a few nanometers (nanorobots) help to build new materials and objects - corresponding dimensions.

(Edwards @ chron.com)

Energy

Nanotechnology is expected to make solar energy more economical, reducing the cost of manufacturing solar panels & related equipment as well as energy storage devices.

(Edwards @ chron.com)

Electronics and Computer Science

The electronics sector is expected to evolve due to nanotechnology applications. Quantum dots, for example, are tiny light-producing cells that can be used for lighting or for purposes such as display screens. Silicon chip can reach its limits - in the recording of integrated circuits - as nanotechnology will allow the construction of circuits with precision at the atomic level, it will be possible to expand these limits.

(Edwards @ chron.com)

Biofuels

Nanomaterials can increase the metabolism of microorganisms and improve the effectiveness of lipid extraction without harming microalgae.

Calcium oxide and magnesium oxide nano-particles were used as biocatalysts in biosynthetic oil distillation, with positive results.

(Singh 2017)

Textile industry

Nanotechnology finds application in textiles as nano-particles provide high durability, increased durability, comfort, lower production costs, etc. The use of nanotechnology allows fabrics to be made multifunctional with special functions (e.g. antibacterial protection (with silver nano-particles), protection from ultraviolet radiation.

(Singh 2017)

Cosmetology - Cosmetics

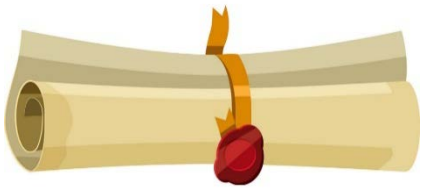
- Numerous cosmetic products (from companies such as Lancome, Kara Vita, Nano-Infinity Nanotech, L'Oreal) based on nanomaterials are already on the market.
- Many products (such as moisturizers, cleansers, anti-wrinkle creams, sunscreens) based on nano-materials are already on the market. Lipo-somes are used in the production of cosmetics as they are biocompatible, biodegradable, non-toxic, flexible and can easily and effectively 'trap' the active ingredients.
- One of the main components of lipo-somes is phosphatidylcholine used in skin care products (moisturizer, lotion, creams, etc.), in hair care products (shampoo, conditioner).

Source: Singh, N. A. (2017). Nanotechnology innovations, industrial applications and patents. Environmental Chemistry Letters, 15(2), 185–191. doi:10.1007/s10311-017-0612-8.

(Singh 2017)

Economic Dimension

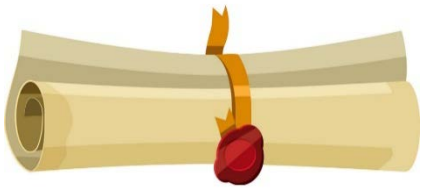
- Nanotechnology, due to the special characteristics of nanomaterials, is widely used in many fields, such as medicine, agriculture, industry, etc. Despite its global applications, the nanotechnology sector is facing significant problems related to the issuance of patents.
- The United States ranks first among the top twenty countries for submitting patents and publications on nanotechnology, while India ranks nineteenth for submitting patents and eighth for scientific publications.



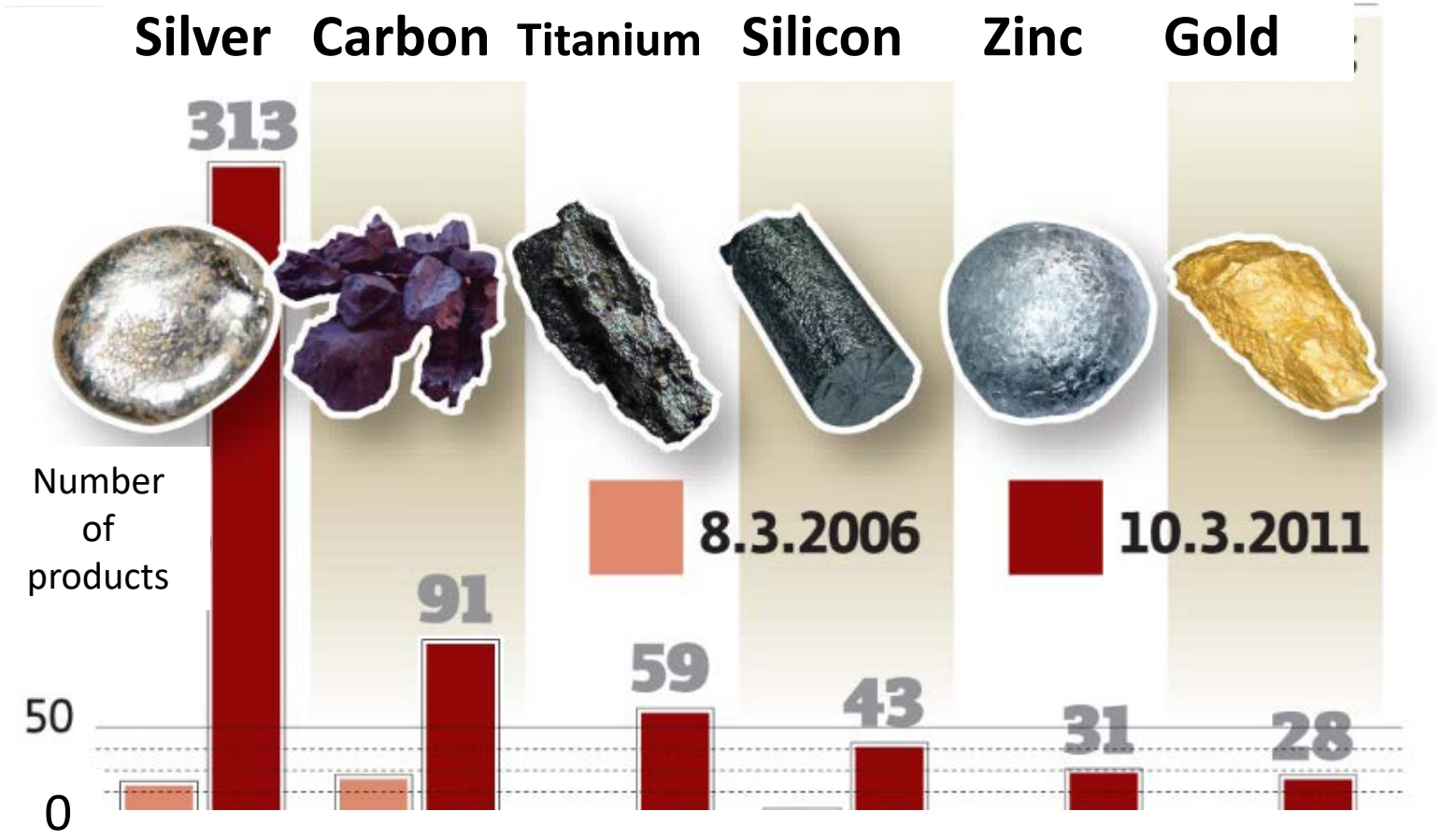
(Singh 2017)

Patents

- https://www.gapminder.org/tools/#$chart-type=bubbles



The main materials from which the nanoparticles are derived



Nanites….

- The nanites are evolving-Star TrekTNG https://www.youtube.com/watch?v=P-3MFjkyRtk

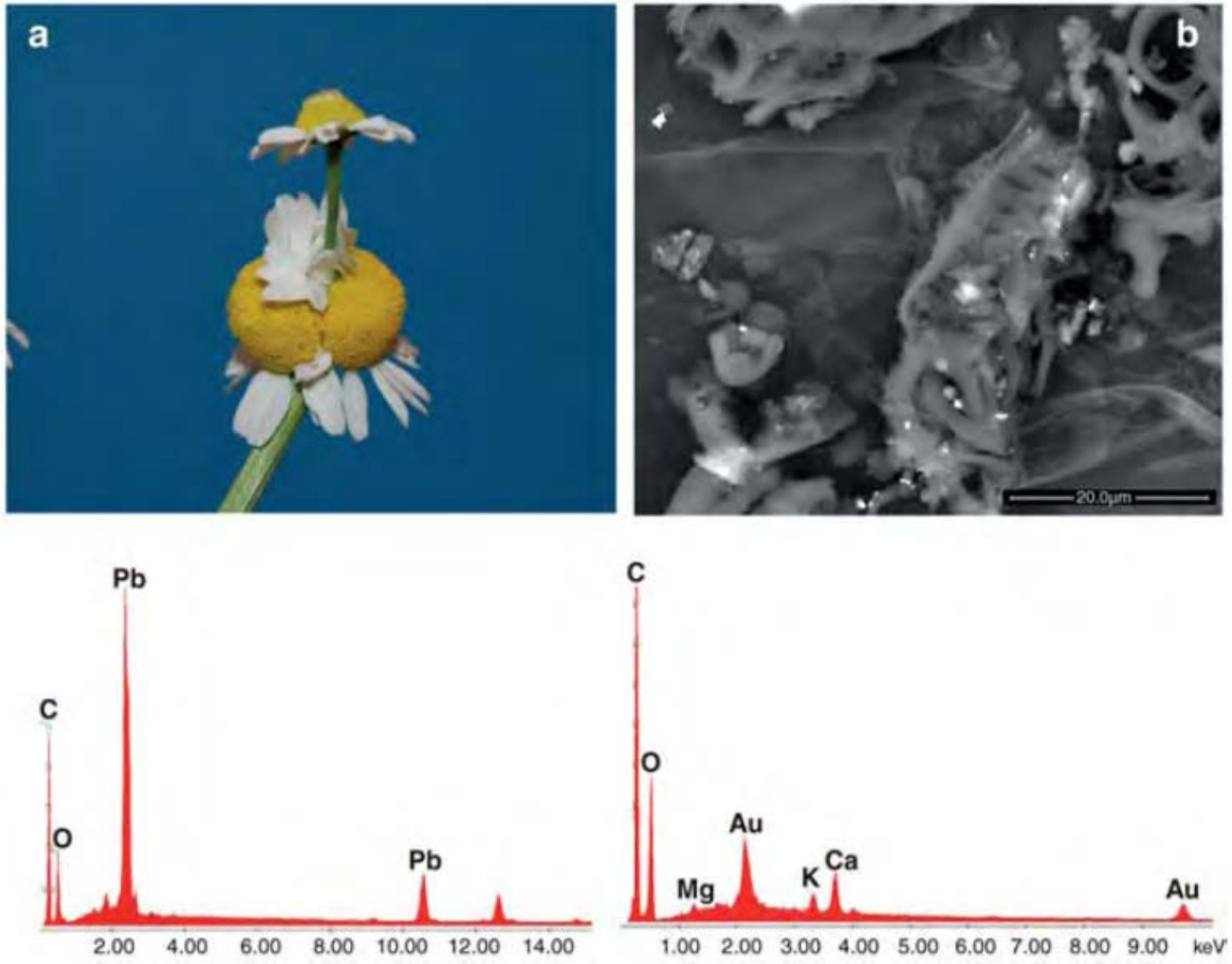
Environment

Leaving out some Science Fiction scenarios (for example, the so-called "gray goo" scenario, where self-copying nano-bots consume everything around them to make copies), is likely to have a negative impact on the environment, as possible new nano-toxins and nano-particles (with unknown consequences) will be found in water, carbon and food circles.

•

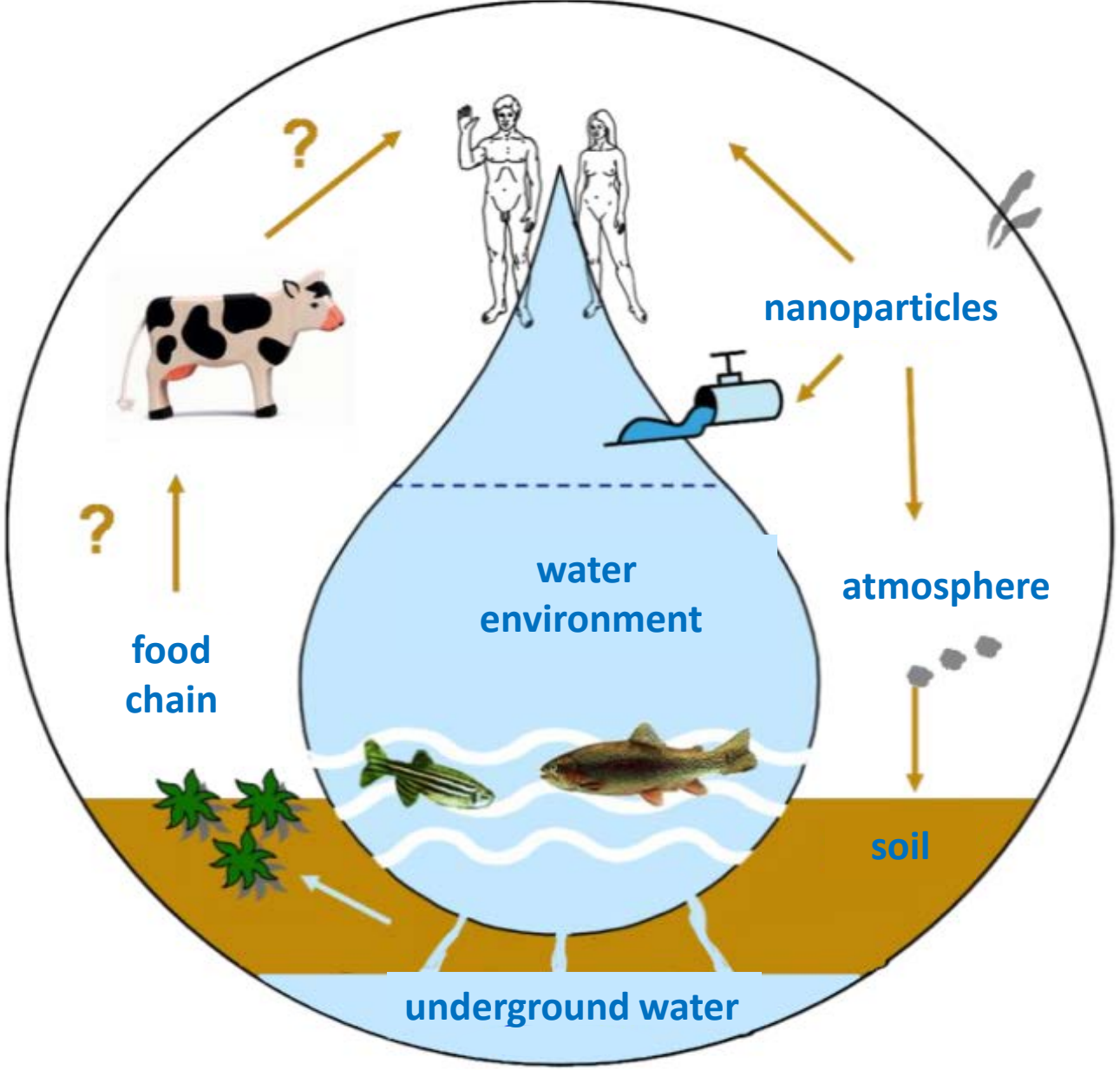
"When artificially made nano-particles are released into the atmosphere, they can undergo different physicochemical changes, which lead to changes in their properties and their impact on the environment. There is a growing concern that human exposure to certain types of such particles can have a significant impact on health. We need to treat nano-toxicity as a new class of toxicity that is little known, giving special weight to sensitive populations, such as children, whose bodies are more vulnerable than adults. "

https://www.tovima.gr/2012/04/22/science/poso-apeilei-tin-ygeia-mas-i-diadosi-twn-nanoproiontwn/



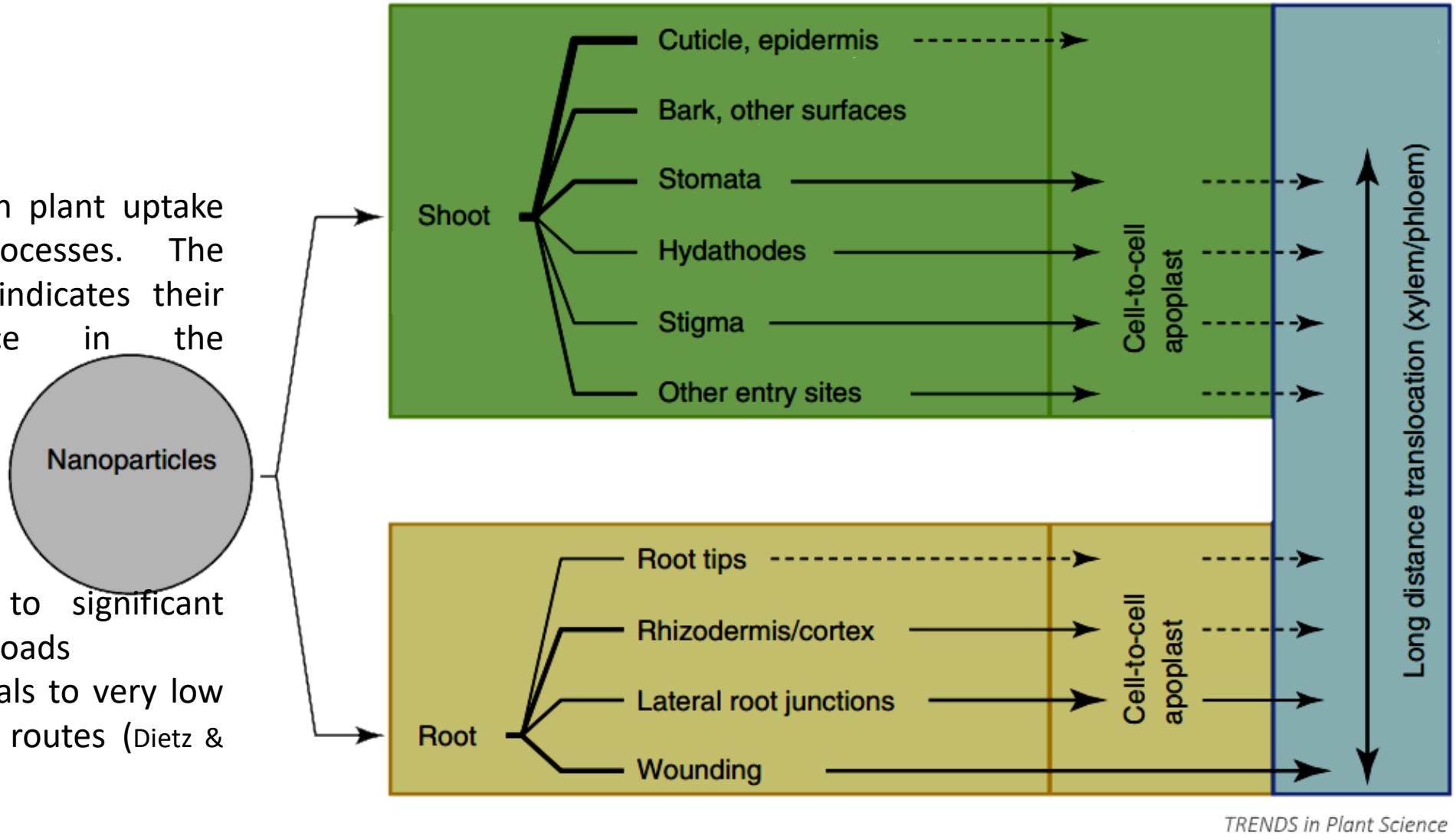
Deformed chamomile flowers. The spectral lines show contamination of lead, gold, calcium, magnesium, potassium.
Gatti & Montanari 2015:254

(*__Plant nanotoxicology__ – Dietz & Herth 2011)



… from the environment
… to man

Nano-somal pathways, in plant uptake and displacement processes. The thickness of the lines indicates their considered importance in the phenomenon:



... thick lines equals to significant transport through these roads
... Intermittent lines equals to very low transport through these routes (Dietz & Herth, 2011)

The research on the use of nano-particles in plant development has already been used as a homeostasis process to obtain specific levels of ingredients that they need. Source: https://www.dovepress.com/nanotechnology-in-agri-food-production-an-overview-peer-reviewed-fulltext-article-NSA

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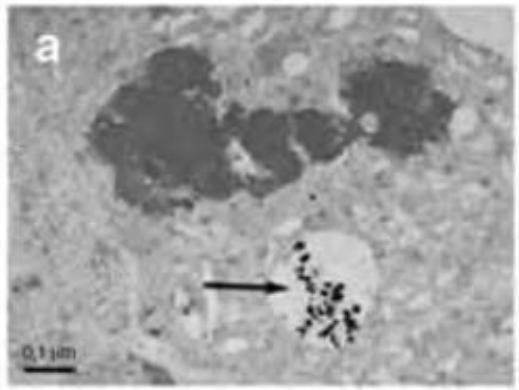
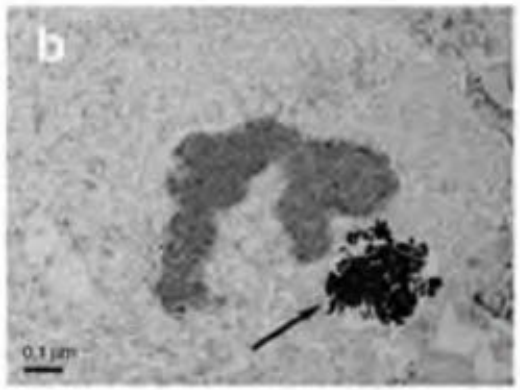
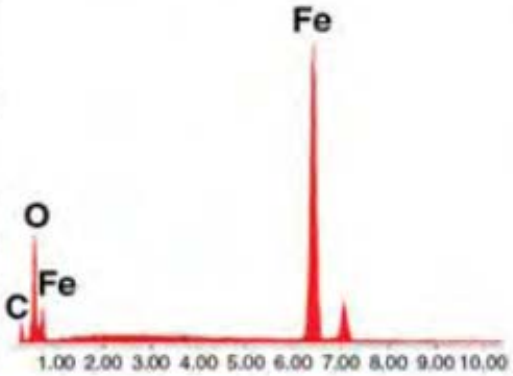
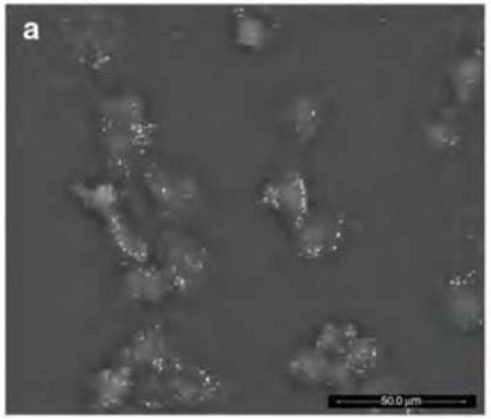
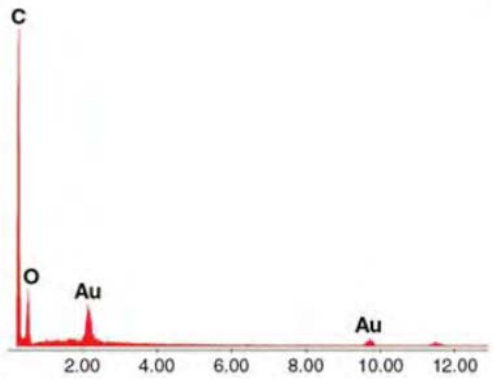
Nanotoxicity







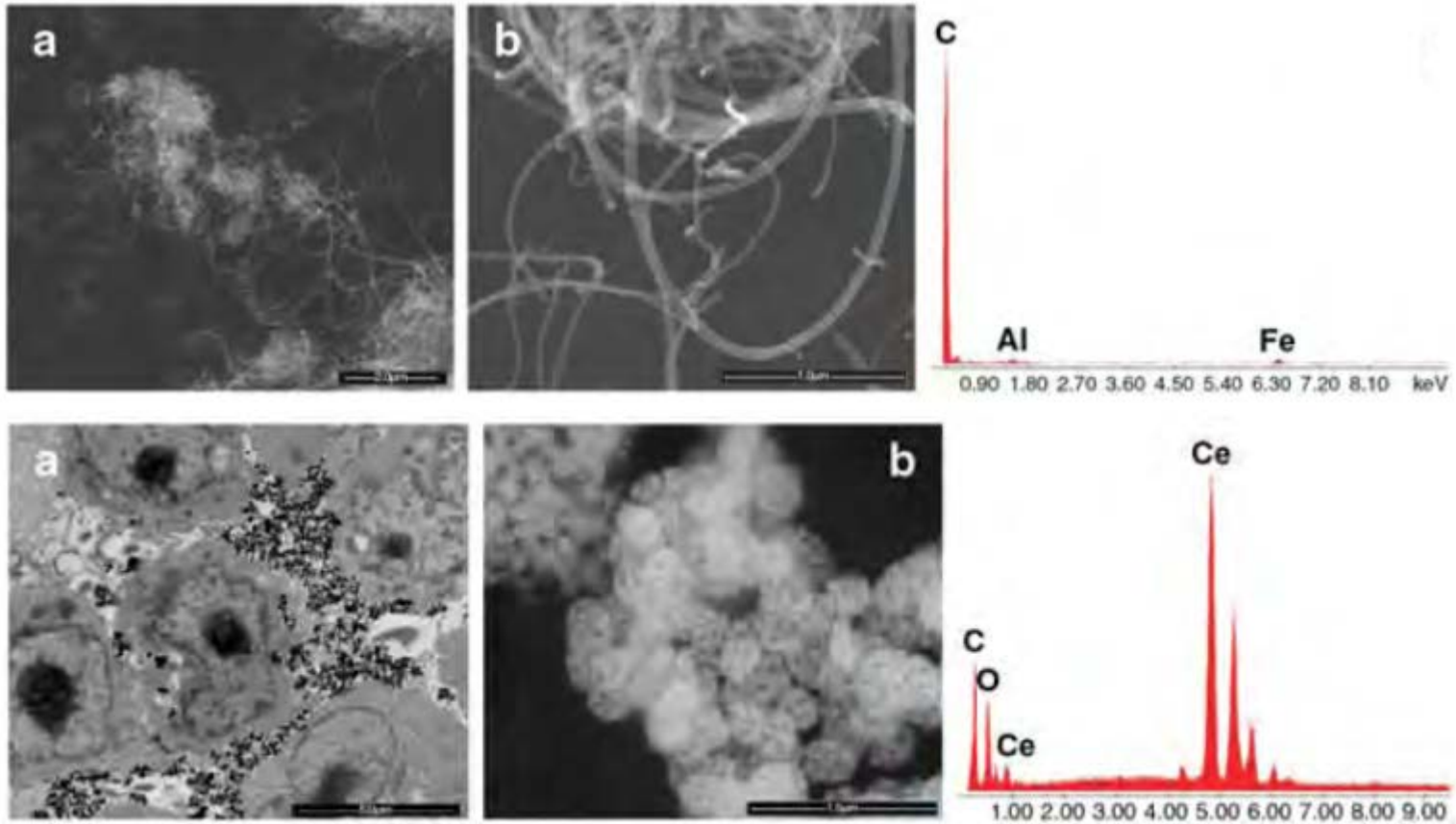




Top photo: a 3T3 cell during mitosis in contact with hematite (Fe2O3)
Bottom photo: 3T3 cells after infection with gold nano-particles (white dots)

(Gatti & Montanari, 2015:19-25)

Nanotoxicity



Above photo: presence of a cluster of nanotubes - in larger enlargement we see pollution from aluminum and iron
Bottom photo:
CeO_2 nanoparticles in 3T3 cells - nanoparticles meet the extracellular space blocking normal cellular communication and movement.
(Gatti & Montanari, 2015:19-25)

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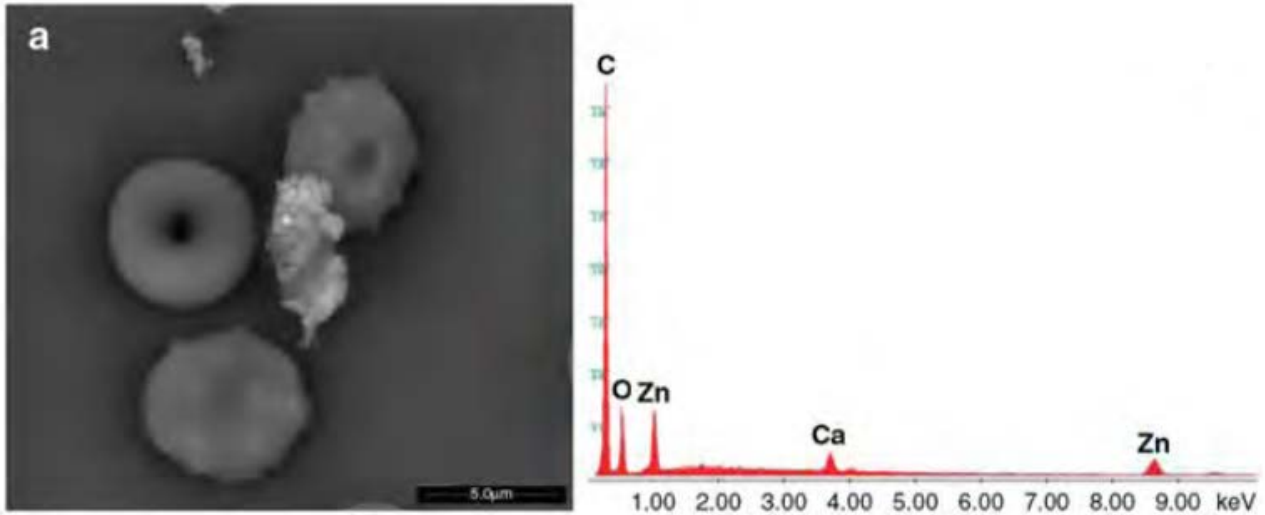
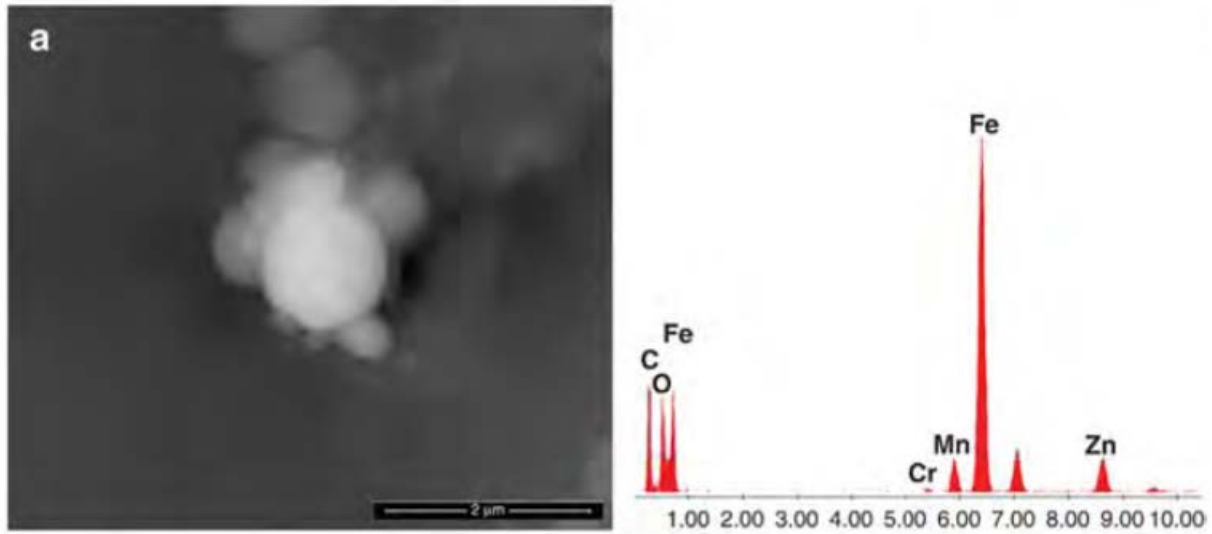
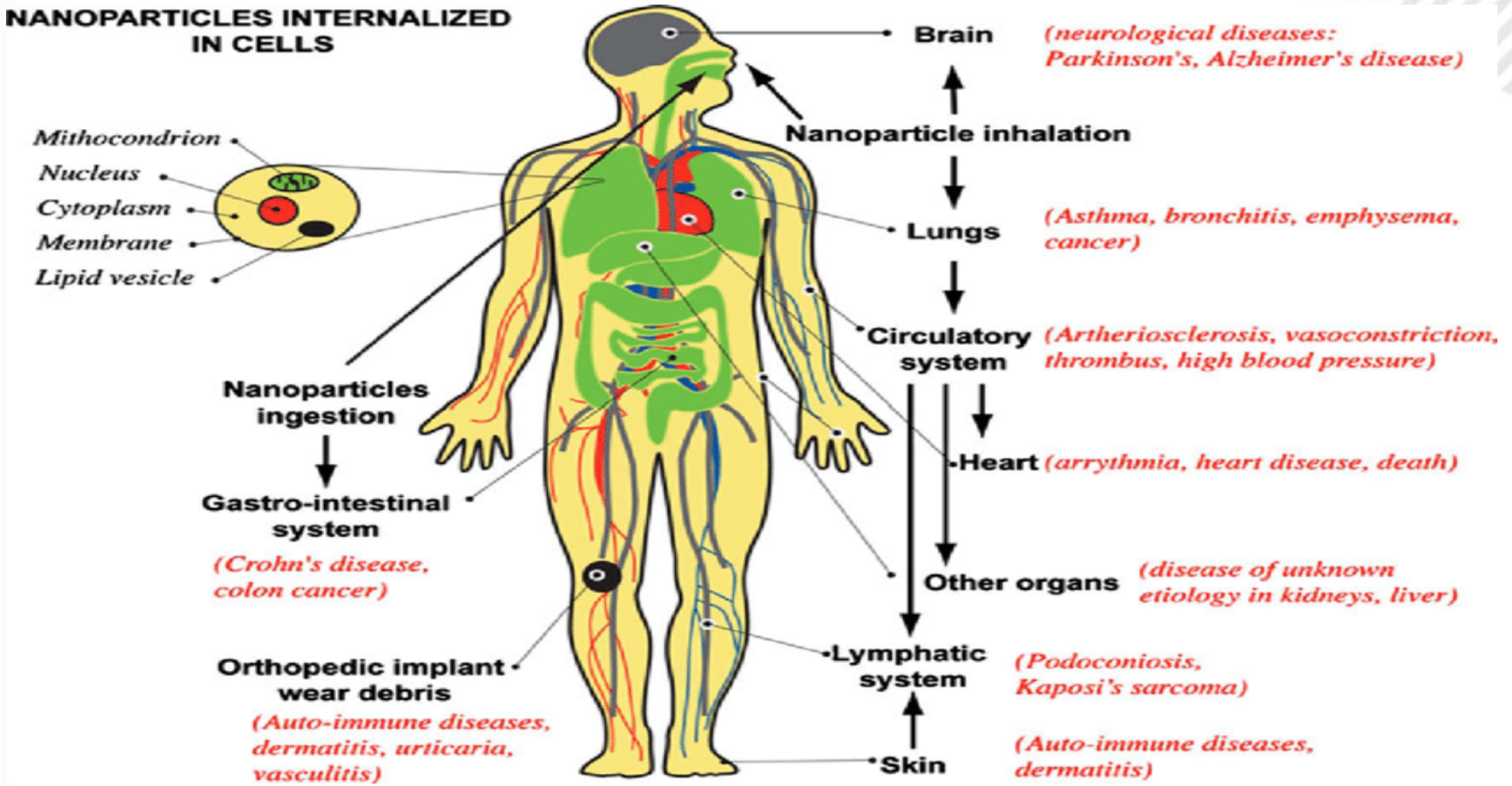




Top photo: Red blood cell with human blood red blood cell and an unusual biological aggregate containing zinc-calcium particle.

Bottom photo: Spherical fragments found in a kidney biopsy. The pellets contain iron, zinc, manganese and chromium.

(Gatti & Montanari, 2015:32,73)



… from the environ-ment … to man…

Subject of Contradiction

The question then arises as to whether the use of nano-materials causes health problems and their use has adverse effects on the environment or whether the problems are limited and the technological applications are, indeed, beneficial to the environment and, consequently, to the human health.

Subject of Contradiction

The use of nano-materials causes serious health problems in humans

Health and Protection Issues

- Silver nanoparticle risks and benefits: Seven things worth knowing
- https://www.youtube.com/watch?v=Yz6LuH-11II

Health and Protection Issues

- Manufactured Nanomaterials: Health, Safety and the Environment
- https://www.youtube.com/watch?v=MkpcUpattE8

- Safety of manufactured nanomaterials
- http://www.oecd.org/env/ehs/nanosafety/
- http://www.oecd.org/env/ehs/nanosafety/45910212.pdf (ΟΟΑΣΑ)

Odyssey
Oxford Debates for Youths in Science Education

Erasmus+

Thank you… Dimitrios I. Sotiropoulos

Odyssey
Oxford Debates for Youths in Science Education

Erasmus+

Notes on the teacher from now on…

Video of the Presentation

- D1. https://www.youtube.com/watch?v=CjpXj2BqJBY
- D.7. https://kapwi.ng/c/lgPpEadq
- D.14. 1. https://www.youtube.com/watch?v=dQhhcgn8YZo
- D.14 2. https://www.youtube.com/watch?v=IGjCOJqINPA
- D.41. https://www.youtube.com/watch?v=P-3MFjkyRtk
- D. 52. https://www.youtube.com/watch?v=Yz6LuH-11II
- D.53. https://www.youtube.com/watch?v=MkpcUpattE8

Correlation of Nanotechnology and School Knowledge Objects

The issue of nanotechnology and the use of nano-materials are related to concepts, phenomena, relationships, and mechanisms contained in school unit sections (listed below).

Therefore, they fall within the cognitive objectives of the curriculum and the instructions, which are additionally sent to the schools each school year.

Related Courses

- **Biology:** 2nd Gymnasium, 3rd Gymnasium, 2nd General Lyceum
- **Chemistry**: 2nd Gymnasium, 3rd Gymnasium, 2nd General Lyceum

Related Courses per class

2nd Gymnasium

- **Biology** (1.2,4.1,4.2)
- **Chemistry** (1.1, 1.2, 1.3, 2.1, 2.4, 3.4)

3rd Gymnasium

- **Biology** (1.2, 2.2, 2.4, 5.1, 5.2)
- **Biology** (4.2, 4.3, 4.6)

Related Courses per class

2nd General Lyceum

- **Biology** (1.1,1.2, 2.2, 2.3)
- **Chemistry** (1.1, 1.4, 2.8, 5.1, 5.2, 5.4)

For example 2nd General Lyceum

In Biology (Units 1.1 and 1.2 (Objectives within the book) students are expected to:

- list the most important groups of organic macromolecules (proteins, nucleic acids, carbohydrates, lipids) and describe their structure. As a result, students are expected to associate macromolecules (proteins, nucleic acids, carbohydrates, lipids) with nano-materials and, knowing in the same section data on DNA and RNA, approach the capabilities of nanotechnology to act on this level.
- In sections 2.2 and 2.3 of the same book, the cell is studied (the relevant objectives are listed in the corresponding file of the introductory training) and students are expected to relate the particular characteristics of the cell to the nano-scale and the possible interactions for the various parts of the cell at the nano-scale level. The sections 1.1., 1.2. of the book of the 3rd Lyceum can be used for the lesson of the 2nd Lyceum (instructions), where the homeostasis (the relevant objectives have been mentioned above) as well as the microorganisms / microbes are studied, while it is expected to be related, and due to scale, to the possible applications of nanotechnology.

For example 2nd General Lyceum

In the subject of Chemistry (Unit 1.1, APS: p. 2678) the students perform:

- link carbon compounds to their applications in chemical technology, biochemistry and everyday life (for example, drugs, biopolymers, dyes, textile fibers, cosmetics),
- interpret the number of carbon compounds based on the structure of the atom C. In general, there is an important reference to carbon, which is a key component of a class of nano-materials and students are expected to assess the value of the element for the development of new materials.
- Section 1.4 discusses isomerism and different properties due to layout (APS, p. 2679) and students are expected to:
- to state what is called isomerism and to distinguish its species.
- This goal is related to the different properties of nano-materials over the rest and it is expected that students will make such a semantic connection.

For example 2nd General Lyceum

In the subject of C**hemistry**

• Section 2.8 discusses the derivatives of hydrocarbon combustion, air pollution, and the effects of industrial emissions (APS, p. 2684). We expect students to take this into account when formulating their arguments and this dimension. Chapter 5 (introduction, sections 5.2 and 5.4) describes substances that are large molecules and are widely used. We expect students to make the necessary connections between polymers (and silicones), which are natural (already existing) or artificial (new) materials and nano-materials.

- In addition, the following objectives are explicitly stated in the APS (p. 2682) which the students seek to:

  •

  - explain that nano-materials are cutting-edge materials with applications in science and technology and

  - to report applications of nano-materials in everyday life.

- Elements that students will approach using the supervisory material and the help of the teacher (no relevant material is included in the official textbook).

At the same time, however, with the help of educational material…

which will be available to teachers and students, will give the opportunity to expand the cognitive field of students in relation to the existing objectives of the curriculum, with the addition of new, related to the individual subjects, which are included on the issue of the use of nanomaterials and nanotechnology applications in general.

The educational guide…

Incorporated into formal education, it proposes an interdisciplinary approach to the subject matter of nanotechnology and its materials.

Through the interdisciplinary activities proposed and the educational material that will be given, the students will get to know the dimensions of the issue, the benefits from the use of nano-materials as well as the possible effects on the natural environment and human health from the use of nano-materials.

Additional notes

- It is important to make it clear that: the proposed sections contain concepts, phenomena and relationships or mechanisms that, potentially, can be related to the present educational material. The correlation will be made with the help of the teachers and in this way - although indirectly - the necessary connection with the existing objectives of the Curriculum for the respective courses will be made. In some (extremely few) cases, the proposed sections are outside the proposed (this year's) material. However, the proposed objectives can be excellent material for the needs of this particular educational guide. Also, concepts and phenomena that exist in the material of previous classes, are considered known and can be mentioned, briefly, based on the reports above.
- For high school students, the educational guide could be applied in the context of school activities, innovative creative research projects (projects), groups but also in any case enrichment and expansion of the teaching of courses referred.

  Such creative work is listed below:

- http://www.iep.edu.gr/images/IEP/EPISTIMONIKI_YPIRESIA/Epist_Monades/B_Kyklos/Genika/2017-10-
- 31_Xhmeia_BLykeioy_nanoylika_ypodeigma1.pdf
- http://www.iep.edu.gr/images/IEP/EPISTIMONIKI_YPIRESIA/Epist_Monades/B_Kyklos/Genika/2017-10-31_Xhmeia_BLykeioy_nanoylika_ypodeigma2.pdf

Terminology Related to Nanotechnology and Nano-materials

Terminology _1

- **Nanomaterials:** Engineered nano-materials (ENMs) are chemicals or materials whose size ranges between 1 and 100 nm (nanometers, 10-9 meters - various classifications: zero dimension (0D) <100nm, such as nano-particles and quantum dots, one-dimensional (1D) <100nm, such as nano-tubes, fibers and nano-wires, two-dimensional (2D) <100 nm minutes and ultra-thin films, coatings, multilayer structures, etc.). Nano-materials have specialized physicochemical properties and quantum properties compared to larger particle materials. The need for new, advanced materials and systems with new properties and behaviors, led to the creation of nano-materials. Procedures for the production of nano-materials include a) a mechanism for depositing atoms or molecules from the gas phase on the surface of a solid material (bottom-up approach) or b) the creation of a specific structure through e.g. ion bombardment, lithography (top down approach) (Vlachogianni et al. 2014, Nano-materials Engineering and Nanotechnology Applications, http://bit.ly/2LyAr9H; Haritidis & Kordatos from the website of the course Nano-materials and Nanotechnology)

Terminology _2

- **Nanotechnology:** is the study and technological application of extremely small objects, which are applied in all other fields of science, such as chemistry, biology, physics, materials science and engineering, pharmacology, etc. Nanotechnology is defined as the field of engineering applications that use molecule-sized structures. The scale for measuring these structures is the nano-scale which gives their sizes in nanometers (nm), that is, in multiples of one billion meters. For the most part, in the field of nanotechnology, interest structures are usually less than 300nm in size. By comparison, the cross section of a human hair is about 60,000nm, a DNA molecule 2 to 2.5 nm, and a water molecule almost 0.3nm. The activities of nanotechnology include the design and construction of materials at the level of the molecule and the individual, as well as the various applications of these materials. Matter, at the levels considered by nanotechnology, exhibits quantum properties, completely different from the properties of macroscopic quantities that surround man in his daily life. Therefore, nanotechnology has an interdisciplinary character, as it combines perfectly with the other sciences whose structures are measured on the same scale (nanoscale), such as quantum physics, chemistry, biology, computer science and microelectronics, etc. http://bit.ly/2JLy8xV
- Fullerenia: Each molecule is in the form of a regular twentieth century, consists of 60 C atoms and resembles a soccer ball. See the figure next to and http://bit.ly/2IUA7OA.

Terminology _3

Carbon nanotubes: are concentric graphite (graphene) cylinders, closed at each end with five-membered rings. They were discovered in 1991 by Sumio Iijima. Nano-tubes can be multi-floating with a central tube surrounded by one or more layers of graphite or monofilament, where there is only one tube and no extra layers of graphite. When nano-tubes are grouped, we have the so-called nano-tube arrays (Wikipedia). See here: http://bit.ly/2XVMtMJ,

- **Nano-toxicity:** When artificially made nano-particles are released into the atmosphere, they can undergo different physicochemical changes, which lead to changes in their properties and their impact on the environment. There is growing concern that human exposure to certain types of such particles can have a significant impact on health.
- **Bioavailability:** Bioavailability refers to new drugs and bioavailability in essentially similar drugs, those whose patent protection has expired and are manufactured by any pharmaceutical company. The definition of bioavailability as determined by the Academy of Pharmaceutical Sciences is 1.2: "The measurement of the relative amount of a given drug that reaches the general blood circulation in relation to the rate at which it occurs."

Terminology _4

- **Oxidative stress:** Oxidative stress in a cell or organism is called the pathological condition, which results from the imbalance between the levels of anti-oxidant mechanisms and oxidizing agents (active forms of oxygen, nitrogen and free radicals) (Ntounoussi, 2009).
- **Simulation:** With this self-adjusting mechanism, the programmed temperature is kept constant, for example in a device such as an ironing iron, regardless of the temperature of the external environment. Similar mechanisms of self-regulation are found in living organisms. In order to function properly, they must be able to maintain their internal environment (composition and amount of liquids, temperature, pH, etc.) relatively stable, regardless of the conditions of the external environment in which they live. This ability is called homeostasis and, in order to achieve it, energy is required. (School C Biology Guide, Chapter 4).

Nano-toxicity

- Laboratory studies have shown that carbon nano-tubes are cyto-toxic and cause granulomas in animal lungs. Other nano-particles, which contain metals and metal oxides (such as copper (Cu), cobalt (Co), titanium dioxide (TiO2) and pyrite dioxide (Si02), have also been shown to have inflammatory and toxic effects on cells. TiO2 nano-particles have been shown to cause DNA damage as well as chromosomal abnormalities. Hydro-xyapatite nano-particles, a substance closely related to the mineral component of bones and teeth, have been found in studies to cause cellulite.

•

Source: Dunphy Guzmán, K. A., Taylor, M. R., & Banfield, J. F. (2006). Environmental Risks of Nanotechnology: National Nanotechnology Initiative Funding, 2000–2004. Environmental Science & Technology, 40(5), 1401–1407. doi:10.1021/es0515708

Additional Videos

- 1 http://bit.ly/2GnNyp8 (TEDx «The next step in nanotechnology»)
- 2 https://youtu.be/VDYD5U5UtR4 (TEDx «Redefining nanotechnology»)
- 3 https://youtu.be/KXwW6F181i0 (TEDx «How Nanotechnology Will Change Our World»)
- 4 https://youtu.be/ZpSZdQUIlpg (TEDx «Nanotechnology: The Spies Inside Living Things»)
- 5 https://youtu.be/UttB1VHXzug (TEDx «The possibilities of nanotechnology»)
- 6. https://www.youtube.com/watch?v=IU4A4h1ACJs (Nanotechnology in Cancer Research | Jessica Winter)

Designed by ibrandify / Freepik

Additional Material

- https://ec.europa.eu/research/industrial_technologies/pdf/nano-brochure/nano_brochure_el.pdf

„ Nanotechnology: Health and Environment ”

Material for Teachers

Methodological guidelines, lesson plan and indicative answers on worksheets

The educational package " Nanotechnology: Health and Environment " was developed within "Oxford debates for the education of young people in the field of mathematics and science" project. It is a key material, facilitating the achievement of primary project goals, including increasing reasoning skills and interest in STEM, which in the future may result in taking up a scientific career.

When preparing students for the debate, one should not neglect the development of such skills as: communication excellence, argumentation or public speaking. Students should improve their ability to persuade effectively, argue properly, reason accordingly and speak out correctly. Composition of texts, using rhetorical means in oral statements, speaking in accordance with the rules of language culture, text interpretation, public speaking and presentation of texts, discussions and negotiations are of equally high importance.

In order to achieve the abovementioned goals, the implementation of thematic educational packages should be preceded by classes dedicated to preparation for debating as such. This can be accomplished in consultation with teachers of other subjects and the class teacher. The development of basic communication skills can be included in the class teacher's work plan, and the prepared lesson plans can be used during regular classes. Auxiliary materials can be found in the following documents:

1. **Warm up practice** – Annex No 2 to National frameworks for implementation of Oxford debates in STEM in school practice ;
   This document includes the following exercises: active listening, public speaking and debating skills.
2. **Lesson plans aimed at general development of debating skills** – Annex No 2 do National frameworks for implementation of Oxford debates in STEM in school practice ;

   This material consists of 7 lesson plans prepared by Dr. Foteini Englezou, president of the Hellenic Institute for Rhetorical and Communication Research. Scenarios are a guide to work. It is not necessary to follow all the lessons. The teacher can decide which scenarios (or their selected fragments) are most useful for working with a specific group of students. The document offers the following lesson plans:

   1. Communication skills
   2. Express your scientific argument, not your opinion
   3. Build a valid scientific argument
   4. Searching for evidence
   5. Enhancing students’ linguistic skills
   6. Rebuttal and refutation
   7. Fallacies

3. **Methodological Guide for Teachers. ODYSSEY: Oxford Debates for Youths in Science Education** (https://odyssey.igf.edu.pl/wp-content/uploads/2019/11/%CE%9F4-IN-ENGLISH.pdf **)**

The final stage of preparation for debates based on specific packages is to familiarize students with the principles of debating, described in detail in the abovementioned document.

Nanotechnology: Health and Environment

The "Nanotechnology: Health and Environment" educational package consists of the following elements:
• Multimedia presentation; See the following link: https://youtu.be/YSI8V83Azf8
• Video- recording based on the presentation;
• Educational package "Nanotechnology: Health and Environment" - material for students;
• Worksheets (the same for all packages);
• "Nanotechnology: Health and Environment" - material for the teacher (with answer key).

It is recommended to implement the package during a minimum of three lesson units.

The 4th Industrial Revolution (4BE / 4IR) has already begun. The countries that seek their evolution, as societies, participate in it by any means and in any way. Pupils, students, professors, universities, institutes, institutes, companies, institutions and politicians actively participate and contribute with their (corresponding) role in it. The main technological dimensions, related to the 4th Industrial Revolution, are: Information Technologies, Artificial Intelligence, Photonics, Nanotechnology, Biotechnology and Robotics.

Looking to the future with a vision and aiming at the active participation of all European countries in the global educational process, it is recommended that students are aware and able to deal effectively with the issue of nanotechnology, which is one of the most important dimensions of the 4th Industrial Revolution.

This educational guide "Nanotechnology: Health and Environment" includes a series of activities, which provide the opportunity to enrich the knowledge of students / three about nanotechnology. It also allows students to formulate arguments highlighting both developments in nanotechnology and the potential risks it poses to human health and the environment.

The controversy on "Nanotechnology: Health and the Environment" can take place during extrajudicial activities related to Biology and Chemistry. The level of material provided is aimed mainly at high school students.

Lesson 1. Introduction to Nanotechnology. What are the benefits and risks of using nanomaterials for human life and the environment?

With the help of the supervisory material of the educational guide "Nanotechnology: Health and Environment", students are expected to:
● get to know the different nanomaterials,
● focus on the solutions and the advantages they offer in their various fields of application (medicine, pharmacology, industry, cosmetics),
• be aware of the potential dangers of their uncontrolled diffusion into the environment.

In addition, students will approach the possibilities for 'inactivating' hazardous nanomaterials or their effects, to minimize the negative effects of their use (for example through their introduction into the food chain).

Finally, they will reflect on the future of nanotechnology applications, which will potentially affect their lives in various ways.

Lesson 2. "The use of nanomaterials causes serious health problems in humans" - creating arguments for and against the subject

The purpose of the second lesson is for students to form as many arguments as possible (for and against the topic), which will be used during the controversy, summarizing the work done with the instructor.

Lesson plan

1. Organizational issues, checking the attendance list, familiarizing with the topic and objectives of the lesson **[5 minutes].**
2. Preparation of arguments: The teacher divides the class into teams of two. Each team receives **12 question cards** available in the educational package (materials for the student) and 2 copies of worksheet No. 1 (one for each student individually). Based on the questions, students formulate arguments for the presented thesis, against the thesis and those that are debatable and can be used in the discussion by both parties. Students work together, but each student individually completes his/her worksheet. There are examples of selected arguments for worksheet 1 are in the answer key. **[25 minutes]**
3. **Teams: proposition and opposition are formed [10 minutes].**

Team selection may be executed in 2 forms, each of them having both advantages and disadvantages.

A) Students declare which arguments are closer to their beliefs. The teacher divides the class into teams (each with a similar number of students) in the manner reflecting their convictions.

B) The second method assumes a division similar to the one above, with the difference that ultimately the team consisting of the supporters of a given resolution becomes the "opposition" team, while the opponents of the thesis become “proposition” team. The supporters of such a division assume that it teaches the participants of the debate to a greater extent to use arguments supported by facts and is less based on emotions. Alternatively, division into teams can also be done randomly.

Finally, team selection can also be made by the teacher in a subjective way, ensuring that each team has both leaders and students who require more help, so that both teams have similar “winning potential”. In order to save time for division, the teacher can do it at the beginning of the lesson, for example by distributing worksheets number 1 to the students, printed on sheets of different colour or marked in some other manner.

1. The teacher distributes worksheets number 2 to the students (one for each student) and explains the homework. An example of a filled-out worksheet is available in the answer key.

2. Students in each team read prepared arguments in accordance with the assignment to a given group. Each student receives 1 argument, which he/she will develop (as homework) according to the guidelines in worksheet No.2.
3. Each team also appoints 3 people who will present the arguments prepared by the entire group. Students decide the order of their speeches. During the debate, other team members who are not directly involved in the debate, fill out worksheet
4. Summary of the lesson, evaluation of students' work **[5 minutes].**

Lesson 3. Debate

During the final lesson, the teams conduct a debate according to the guidelines contained in the " Methodological Guide for Teachers. ODYSSEY: Oxford Debates for Youths in Science Education".

It takes 45 minutes in total to conduct a full debate. During the debate, the teacher does not comment on the arguments or indicate the fallacies made by the students on an ongoing basis.

An exercise-based debate should be structured as follows:

1. Opening of the debate by the moderator/chairperson [3 minutes].
2. Initial vote by the audience [2 minutes].
3. 1st Researcher-Debater of the A research-team: Constructive Speech [4 minutes].
4. 1st Researcher-Debater of the B research-team: Constructive Speech [4 minutes].
5. Cross-fire between the researchers-debaters (1) of both research teams [3 minutes].
6. 2nd Researcher-Debater of the A research-team: Rebuttal Speech [4 minutes].
7. 2nd Researcher-Debater of the B research-team: Rebuttal Speech [4 minutes]
8. Cross-fire between the researchers-debaters (2) of both research teams [3 minutes].
9. Preparation time for the Summary and Final Rebuttal by both research teams [2 minutes].
10. 3rd Researcher-Debater of the A research-team: Summary Rebuttal [2 minutes].
11. 3rd Researcher-Debater of the B research-team: Summary Rebuttal [2 minutes].
12. Grand Cross-fire between the researchers-debaters (1 & 2) of both research-teams [3 minutes].
13. 3rd Researcher-Debater of the A research-team: Final Focus Rebuttal [2 minutes].
14. 3rd Researcher-Debater of the B research-team: Final Focus Rebuttal [2 minutes].
15. Final vote by the audience / Short written feedback [3 minutes].
16. Presentation of the results by the moderator [2 minutes].

If the debate takes place during extra-curricular activities, then it is recommended to devote, for example, 90 minutes for this part. This will allow you to prepare the room for the debate, recall the rules, conduct the debate and discuss its course and finally evaluate the work of students.

In terms of classroom conditions, it would be ideal to allocate two adjoining lesson units to the debate. Taking into account the school circumstances, organizational difficulties and the inability to devote too many lessons to content extending the core curriculum, the debate can be conducted in one lesson, while maintaining high discipline in time. In this case, it is recommended that during the next lesson with the class additional 10 minutes are spent discussing the debate, pointing to strengths and mistakes made by the participants of the debate.

In this format, 6 students (3 from each team) actively participate in the debate. The teacher may also appoint a moderator from among the students and a time keeper. The rest of the students will receive worksheet number 3. Their task will be to listen carefully to the debate and to note the opposing team's strengths and areas for improvement, and to justify their choice. Completed worksheet no. 3 may be the basis for issuing a grade for activity in the lesson for students who did not take part in the debate directly, but participated in its preparation and were active observers of its course.

Worksheet no. 1 Questions and indicative answers

The educational package contains a set of questions to help prepare arguments for discussion on the resolution. On their basis, prepare a set of arguments and group them into those that are clearly in favor of the resolution, against the resolution, and those arguments that can be used by both teams. Write them down in the appropriate parts of the table.

FOR	„GREY AREA"	AGAINST
Is there really a large presence of nanomaterials in 'everyday life' and what effect can this have on the health of the population? Indeed, refrigerators, wall paints, space, cosmetics, sunscreens, fabrics, food packaging, etc. have high percentages of nanomaterials in their composition and materials. These materials escape into the environment with significant potential for contamination **(see. IC.6,7,10,13,14, KI.3)** **Should we treat nanotoxicity as a new category of toxicity, of which little is known, with particular emphasis on susceptible populations (e.g. children) whose bodies are more vulnerable than those of adults?**	**How ... old is nanotechnology?** The idea was attributed to Professor R. Feynman in 1959. The term "nanotechnology" was coined by Professor N. Taniguchi in 1974. In 1981 the detection microscope (STM) was invented in Zurich. **(see. SC 3,1,9)** **What effect can the need to produce nanomaterials have on the process and the purchase of the 'raw materials' required?** There are still no clear production figures and reports of raw material shortages. One reason is the tiny ... atomic quantities required to produce nanoparticles. **(see IC 6,7 & SC 2)** **Do you see differences in the 'tolerable' or 'permissible' values of nanoparticles in different organisms in the table below? Where do you think**	**What do you consider the most important applications of nanomaterials?** Fullerene in its various forms, has applications in cosmetics, pharmaceuticals, lubricants (for machine parts), as well as electronics (giving flexible and cheap electronics that multiply the possibilities and applications). *Polystyrene chloride beads make it possible to purify water and nanoscale membranes achieve water desalination, thus solving two of the most important issues of the developing world (water and clean water).* Nanotubes, fibers and nanowires (nanowires, cantilevers) as thin and ultra-thin films as well as nanoshells enhance medical applications for incurable (hitherto) diseases. "Nano-robots" open new and promising horizons for many applications in the near future. **(see IC 1,5,10,12,13,14 & SC 4,8)**

Yes. On the one hand, there are no clear production numbers from the production companies - which also creates problems in environmental impact assessment, and on the other hand, extensive exposure to nanoparticles is very dangerous. **(see IC 6,8,15,16 SC 7)**

How likely is it the (uncontrolled) release of nanoparticles into the atmosphere and what effect can this have on public health?

Very likely and it can not be ruled out. Mostly, however, there is water contamination. There is a report of possible contamination at various stages of the food chain **(see IC 6,8,15,16 & SC 5,7)**

Are there any biological effects of nanomaterials on both animals and plants?

Clearly yes, indicatively:
Infections of cells, organs and genetic material **(see IC 6,8,14,15,16 & SC 5,7)**

this is due and what effect can this have on our health?

Each limit corresponds to modern (epidemiological)

Type of Nanomaterial	BSI (United Kingdom 2007)	IFA (Germany 2009) & SER (Netherlands 2012)	SWA (Australia 2012)	NIOSH (USA 2013)
fibers	0.01 fibers/cm^3	0.01 fibers/cm^3	0.1 fibers/cm^3	0.007 mg/m^3
Granular	20 000 particl./ cm^3	40 000 particl./cm$_3$	0.3 mg/m^3	0,003 mg/m^3

research, socio-economic-political needs and is directly related to the type of material **(see IC 9)**

(see IC 6,7 & SC 2)

Which are the positive uses of nanotechnology?

They are extremely numerous and are growing day by day solving important problems in the fields of health, technology, contributing to the improvement of the quality of life.
(see IC 1, 4,6,7,10,12,13,14 & SC 8)

Does nanomaterial research have anything to do with medicine?

Clearly, yes. Indicatively, we can mention many important results in the fight against diseases such as Parkinson's, Alzheimer's and in the treatment of various forms of cancer. (see IC 12 & SC 8)

Can the economy of a country conducting nanotechnology research be strengthened?

The creation of new materials and applications (nanotechnology) emerges through research and the creation of new patents. The process itself is closely linked to growth in the economy. Nanotechnology is admittedly very promising in innovative applications contributing to overall economic growth. A simple example is that of the future development of a large number of

		applications using Fullerene (typical nanomaterial), which clearly reinforce the above reasoning. **(Presentation Material, SC. 10)** **Can there be countermeasures to nano-pollution using nanomaterials?** The way to control any form of pollution is the continuous controls and the establishment of limits and safe exposure values. Controls with predicted values, limits and new control methods as well as innovative "inactivation" methods are the solution in the case of nanomaterials (e.g. ultrasound devices). **(see Presentation Material, IC 10)**

The projest has been funded with the support of European Commission within ERASMUS+ program

Worksheet no. 2 -Examples of arguments

Based on the materials provided by the teacher, prepare arguments for discussion. One group of students prepares arguments supporting the resolution, the other one - opposing arguments. Use the proposed template.

ARGUMENT nº 1

Argument with reasoning	Foreseen rebuttals of the other group	Answers to rebuttals
The use of nanomaterials poses significant health problems, as research has reported irreversible side effects in living organisms as a result of their exposure to nanomaterials, especially in relation to cellular functions such as cytotoxicity and inflammation due to their size. **(see IC 2,15 & KI. 7)**	In contrast, nanotechnology (NT) applications include the handling of materials on an individual scale with which we have developed techniques and nanomaterials that protect and shield human health such as, for example, innovative desalination and biocide systems in water systems. **(see IC. 4,5,13)**	Some of the drugs or therapeutic strains used through nanotechnology applications in laboratory studies may show very good results, but in reality (in clinical practice) they do not seem to have the same good results. (**see SC** 8)
In addition, research has reported irreversible side effects in living organisms as a result of their exposure to nanomaterials, such as organ damage or even the impairment of important functions, such as blood-brain barrier function due to the small size of the materials. and their interactions due to their size **(see IC. 12)**	On the contrary, applications of NT target individual cells and, in fact, have a particularly positive contribution to the research of understanding the blood-brain barrier, in addition to better understanding the biological functions under study. For example, similar applications have made a particularly positive contribution to research on Alzheimer's disease and Parkinson's disease. **(see IC. 8 & SC 5)**	In gene therapy, the safety results of using nanotechnology techniques are unclear as the nanoparticle handling techniques used can bypass the human body's defense mechanisms, which could mean that less desirable nanoparticles could penetrate cells. or cross natural obstacles. **(see SC 5)**

ARGUMENT nº 2

Argument with reasoning	Foreseen rebuttals of the other group	Answers to rebuttals
The creation of nanomaterials is dangerous, since nanomaterials behave in a completely different way at the atomic level (quantum behavior) than these same materials in larger (macroscopic) dimensions. **(see IC 5,6,8)**	We learn from nature itself (gecko lizards, mussels) using its methods and materials to develop highly innovative materials, which are, we would say, natural. NT allows us to handle and configure them properly. **(see SC 9,8,12)**	There is no easy and complete way of intervention since there will be the diffusion of such materials in the environment since we do not have any possibility of binding such materials **(see SC 2).**
In addition, the escape (due to accident) and the disposal (as waste / garbage) of nanomaterials in the environment, brings incalculable and incompletely estimated consequences of nanotoxicity, as the materials are dispersed in the aquifer, enter the food chain and consume consumers. **(see IC. 5,6,8)**	We learn from nature itself using the methods and materials already present in it, to develop highly innovative materials of carbon structure (such as fullerenes) - so we would say that the materials created are natural. NT also allows us to configure them properly, so that they can be used properly. **(see SC 10)** Instead of water chlorination which provokes many problems water desalination can be achieved using nanotechnology with very good results **(see IC 4, IC 5, IC 13).** We can also mention the significant and positive effects on subsoil enrichment and plant growth. **(see IC. 10 & IC 15)**	Limited amounts are available for research into the effects of nanotechnology materials on the environment and, therefore, we have no knowledge of the quantities and effects of nanomaterials in nature. When the product life cycle ends, the remaining nanomaterials are potentially dangerous entering the water cycle and the food chain making it unclear exactly what we drink and eat (in the amount of nanoparticles) **(see IC. 7,8, SC. 6).**

ARGUMENT **nº 3**

Argument with reasoning	Foreseen rebuttals of the other group	Answers to rebuttals
The contribution to the economy from the applications of NT is not important and they do not help so much in the development of the economy. They seem to be consuming financial resources rather than creating new ones. **(see SC 11)**	The uses of NT have offered many positive applications for faster production with cheaper and higher quality products in cosmetology, industry and electronics. **(see IC 14)**	Huge sums are spent on research into the development of nanotechnology applications, with a rather uncertain result as to the widespread use of its final products (nanotechnology). **(see SC 11)**
	The global economy is receiving positive support from nanotechnology and its materials creation. A typical example of a significant contribution of nanotechnology to new applications and therefore new financial resources, is the field of electronics with the production of cheap flexible digital technology circuits that are known to drive the chariot of the economy. **(see IC. 6,10,14)**	There are chances for socio-economic upheavals that will be caused by the massive job loss that will follow the expansion of the Nanotechnology industries. Countries whose economies are based on trade in raw materials, such as cotton or copper, may be affected by the replacement of these materials by nanomaterials **(see SC 11).**
	Nanotechnology applications use tiny quantities (obviously of low cost) to produce nanomaterials. **(see IC. 6,7 & SC. 2**)	

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Worksheet no. 3

Name and surname: ……. Class……. Team: Proposition/Opposition

During the debate, hear and observe carefully the speeches of the debates from the other team. Then, evaluate which speech convinced you the most and which areas of your opponents' speech should be improved.

1. In terms of argumentation (e.g. the quality of the arguments presented, credibility of the data and scientific evidence) in the rival team I was most convinced by the speaker No. .....

Reason:

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2. In terms of the style of presentation and communication with the audience (e.g. confident, persuasive, authentic and dynamic posture, moderate gestures, assertive voice variety, good eye contact with the audience, use of moderate humor, friendly and professional approach to all participants, effective use of body language) in the rival team I was most convinced by the speaker No. .....

Reason:

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Indicate the element of the rival team's performance that requires improvement. Justify your answer.

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Reason:

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