Committee: United Nations Environment Programme (UNEP)

Issue: Microbes and nanotechnology to save the planet

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Position: Deputy President

INTRODUCTION

Personal Introduction

Dear delegates,

My name is Christos Papanikolaou and I am a student at the Arsakeio High-School of Ioannina. I am one of the three Student Officers in the UNEP committee for this year's conference and look forward to sharing an amazing MUN experience with you all.

The UNEP committee is in my opinion one of the most interesting ATSMUN has to offer, since it pertains to many pressing issues concerning the environment. MUN conferences have not only given me the opportunity to express my beliefs on a plethora of interesting topics, but debate from the viewpoint of different countries as well. The MUN process will help you grow, identify your talents and utilize them, as this topic will offer a lot of fruitful debate.

With this research report I hope to introduce you to the given topic, as well as assist you with your preparation and help you maneuver through all of the information available. Of course, that does not mean that you should limit yourselves only to this study guide, as it is crucial that you make your own research in order to have a well-rounded stance on the issue.

Do not hesitate at all to contact me via email (ckpapanikolaou@gmail.com) if you have any questions or are in need of any clarifications regarding the topic or anything in general.

Yours truly,

Christos Papanikolaou

Topic Introduction

The increasingly alarming rates of air, water and land pollution of the last century have triggered an urgent need to save the planet. A looming climate crisis, caused by a plethora of environmental problems, has signalized a necessary change in the measures taken to improve the situation. Certain factors have and are still aggravating the deteriorating condition of our planet. The means through which said change could be accomplished vary, with the prevailing ones lacking in efficiency. Previous attempts to solve current problems that are plaguing the environment have proven semi-efficient or have even backfired.

However, newly developed technologies such as nanotechnology could be the catalyst when discussing the mitigation of ongoing environmental issues. Such innovative technologies could meet the current need for more sustainable and inexpensive technologies. Focusing on smaller scale technologies, would be the way to revolutionize how we cope with the problems, since such inventions would lead to a more sustainable and eco-friendly future.

With their being able to effortlessly integrate into natural terrain, the extensive infiltration of natural habitats via heavy machinery and infrastructure, which was previously utilized, could be avoided. Moreover, bearing the current environmental vulnerability in mind, having bacteria and microbes produced and cultivated at such fast pace would significantly assist conservation and restoration efforts.

Nanotechnology and the use of microbes, just like any other new technology, could be a focal point for potential solutions to a lot of the world's current and future problems, yet create new problems of their own. Since research and findings have been relatively new, little is known about nanomaterials' toxicity, exposure and overall side-effects. Public opinion, as well as several governments', seems to be uncertain and skeptical over the launching and integration of nanotechnology in various fields.

DEFINITION OF KEY TERMS

Adaptive Materials and Structures

Materials and structures are characterized as adaptive when they change certain properties based on the conditions (humid, dry, etc.) surrounding them. Those materials and structures can adapt and respond to their surrounding environment, optimizing their efficiency and performance.

Bioinspired Robotics[1]

"Bioengineers have borrowed inspiration from nature and concepts from materials/engineering community and have developed bio-inspired robots. These biorobot actuators are able to mimic, and even overcome the performance limitations of living organisms in some cases, thus opening new venues in bio robotics research. Moreover, natural mechanisms (therefore bio-inspired robotics) are generally self-sustaining, high-performance, and efficient with low-energy requirements."

Ecosystem[2]

"An ecosystem is a system in which living things (plants, animals, bacteria, etc.) and their non-living surroundings interact as a functional unit." It is called a functional unit because different components and organisms interact, maintaining a self sustaining and independent ecosystem.

Green Technology/Sustainable Technology

Green Technology (Green tech) refers to means of tech which take into account the environmental impact of their actions. It involves the use of technology in production processes using sustainable forms of energy, such as solar, wind and geothermal energy. Examples of green tech include the technology infrastructure used to recycle waste, purify water, create clean energy, and conserve natural resources.

Microbes

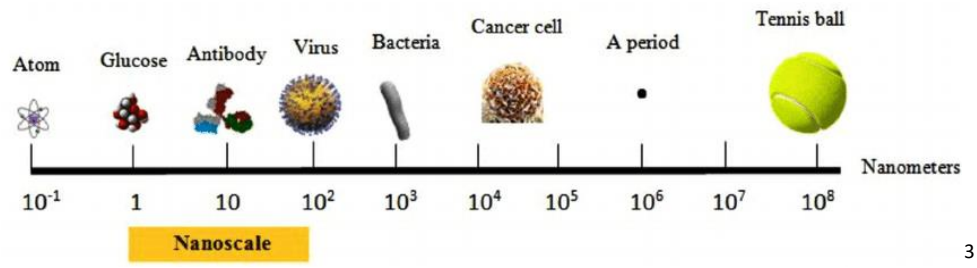
Microbes, also known as Microorganisms, are germs that are responsible for the maintenance of life on planet earth, as well as the cause of many diseases. Some microbes include bacteria, protozoa, fungi, algae, amoebas, and slime molds. They vary in cellular structures, with some being unicellular (comprised of only one cell) and others multicellular (comprised of more than one cell). All play a significant role in terrestrial life and the environment in general, since they serve many functions in almost any ecosystem on Earth, such as decomposition and nitrogen fixation.

[1]https://www.researchgate.net/publication/322405925_Electrically_Driven_Microengineered_Bioinspired_Soft_Robots

[2] "Lex Access to European Union Law." *EUR*, eur-lex.europa.eu/summary/glossary/ecosystem.html.

Nanotechnology

Nanotechnology is a branch of science and engineering conducted at the nanoscale, which is about 1 to 100 nanometers ($1e^{-9}$ of a meter). It is utilized in all scientific fields, including chemistry, biology, physics, materials science, and engineering. Through Nanoscience and Nanotechnology, materials on an atomic or molecular scale can be manipulated, where the chemical and physical properties of materials often change.



[3]

Figure 1.3

Patent

The legal right to create or sell an innovation for a set period of years.

Pollution[4]

"Pollution is the introduction of harmful materials into the environment. These harmful materials are called pollutants. Pollutants can be natural, such as volcanic ash. They can also be created by human activity, such as trash or runoff produced by factories. Pollutants damage the quality of air, water, and land."

Sustainable Development

Sustainable development is a principle, whose goal is to meet human needs for development without undermining and compromising environmental, social and economic implications.

[3] *The Nanoscale*. userscontent2.emaze.com/images/a1069722-d83d-4e3f-9461-5ff28a7e7cb3/e9da37ca8c2800d12dc309d1359b33ca.png.

[4] National Geographic Society. "Pollution." *National Geographic Society*, 9 Oct. 2012, www.nationalgeographic.org/encyclopedia/pollution/.

BACKGROUND INFORMATION

The Importance of Microbes

Microbes can be found practically everywhere and have an impact on almost every part of our life. The vast majority do not damage us, and many are necessary for human, animal, and environmental health. Microbes contribute to the health of the planet by recycling waste and providing nutrients. Some are essential to agricultural systems, while others are dangerous pests. Microbial processes are used in industry to manufacture food and pharmaceuticals, which benefits society and generates revenue.

Antibiotics and pollution from household chemicals are penetrating the delicate ecosystems of microbes, producing important microbiome population imbalances. Wastewater, which contains antibiotics and other pollutants, seeps into rivers and wetlands, killing essential microorganisms. Significantly, wastewater contamination harms ecosystems while also contributing to the rise of antibiotic resistance (AMR).

Microbes can be engineered to provide alternative energy sources to replace fossil fuels, clean up harmful emissions from heavy metals and toxic chemicals, produce new materials from renewable sources, and be the start a new generation of nanoscale machines, all of which can help humanity solve a variety of problems.

Microbes and the Environment

- Renewable Energy

Researchers have used small conductive hairs from electroactive bacteria, positioned them between two electrically conductive gold plates, and discovered that the system generated electricity instantaneously. This system draws power directly from the air, presumably by taking advantage of humidity changes. Researchers discovered that such devices might be scaled up to exceed today's commercial solar panels, noting that they would also work at night.

- Water Purification

While humans have generally considered sewage to be a waste product, bacteria have always considered it to be food. Bacteria play a crucial part in wastewater treatment plants because of this. Since industrial wastewater is generally high in energy, scientists have discovered a method of cleaning it that produces more energy than it consumes, with microbes essentially feeding off of the complex carbohydrates and proteins found in the water.

- Greenhouse Gases

Although normally the faster-growing microbe species prefer to eat sugar over CO_2 - the most prevalent greenhouse gas-, scientists were able to manipulate the microbe "E-coli" to feed off only CO_2. Moreover, they theorize that because E-coli is assisted by formate (a chemical made from renewable power from solar panels), a solar panel using the E-coli could be 10 times better than photosynthesis at minimizing CO_2 emissions from the atmosphere.

- Pollution from Plastic

Bacteria are able to detect and degrade plastics, further contributing to the cleaning of the planet and being able to break down waste that has been contaminating the earth for over a hundred years.

Potential Risks of Microbes

Microbes are microscopic organisms that cannot be seen with the naked eye. Microbes can make us sick by functioning as infectious agents, even though most of their interactions with people are neutral or beneficial. Microbes can infect a range of body organs and systems, causing sickness to spread throughout the entire system and human body.

Only a few dangerous germs, less than 1% of bacteria, can infiltrate our bodies and cause illness. Infectious diseases such as the flu and measles are caused by microbes. Microbes are also thought to have a role in a variety of non–infectious chronic disorders, including cancer and coronary heart disease. Different sorts of microorganisms produce different diseases.

Microbial contamination of food is a major public health hazard around the world. Over the last few decades, most countries have seen large increases in the incidence of diseases caused by microbes in food. Bacteria such as Salmonella, viruses such as Norovirus, parasites such as trematodes, and prions are all examples of microbial risks in food.

The Evolution of Nanotechnology

Early implications of nanotechnology have been spotted all throughout history. From ancient Rome's masterful Lycurgus Cup to the stained glass windows of the medieval times, nanotechnology has been used unknowingly for ages. For example, the gold used in the aforementioned Lycurgus Cup, among others, is characterized as colloidal, which means that the substance's dimensions can range between 1 and 1000 nanometers. As a result of the

empirical use of this technology, the cup is able to change colors, depending on whether it is lit from the inside-out or vice-versa.

 [5]

Figure 2.5

However, conscious research and usage of nanotechnology did not begin until 1959, where the father of nanotechnology, Richard Feynman presented the idea of manipulating particles on an atomic level, during his lecture “There’s Plenty of Room at the Bottom”. The notion of controlling and processing substances at such a small level was introduced a few years prior, with the term “nanometer” being first mentioned by Nobel Prize Laureate, Richard Zsigmondy.

What ignited the expansion upon nanotechnology was the invention of the scanning tunneling microscope by Gerd Binnig and Heinrich Rohrer at IBM’s Zurich lab. The microscope enabled scientists to “characterize in a quantitative way the surface complexities of materials”. In 1979 Eric Dextler became interested in Feynman’s work, publishing the article "Molecular engineering: An approach to the development of general capabilities for molecular manipulation". Based on the foundation of Feynman’s work, as well as assisted by new discoveries in the scientific field, Dexter was able to reinforce previous concepts of what nanotechnology could be.

In 1986, the publishing of his book “Engines of Creation: The Coming Era of Nanotechnology” and the founding of the Foresight Institute, helped popularize and bring awareness to the concept of nanotechnology. Moreover, the late 80s and 90s saw the rise in companies occupied with nanotechnology such as Nanophase Technologies in 1989, Helix Energy Solutions Group in 1990, Zyvex in 1997, Nano-Tex in 1998.

[5] *Lycurgus Cup*. www.researchgate.net/profile/Rochelle-Arvizo/publication/221886246/figure/fig10/AS:668554206642184@1536407152534/The-Lycurgus-Cup-1958-12021-in-reflected-a-and-transmitted-b-light-Scene-showing.png.

Applications Concerning the Environment

- Air Pollution

Air pollution is one of the most prevalent problems of the 21st century. Whether it is anthropogenic, geogenic or biogenic, visible or invisible, the effects it can have on one's health and the environment are extremely hazardous. Due to air pollution, two of the most well-known environmental phenomena are caused: the greenhouse effect and the ozone hole.

In order to filter harmful gas emissions introduced into the atmosphere, catalysts have been used to transform the vapors released from cars, trucks and factories into nonhazardous gasses. Scientists can chemically transform pollutants by either reducing or increasing electrons of a reactant (oxidation-reduction). Via adsorption, the reactants are essentially "stuck" on the surface of the catalyst, which leads to the rearrangement of the electrons and weakening of the harmful chemical bonds. Nanotechnology could help amplify the results of such practices since the smaller scale particles make up for a better surface area for scientists to work on. This increases the effectiveness of the catalyst, because more chemicals are allowed to interact with it.

Moreover, nanotechnology is able to mimic structures found in nature, such as those of a butterfly's wings. Whereas normal catalysts are expensive, since they make use of precious metals such as platinum, bioinspired nanotechnology enables the creation of a surface area, where catalyst particles could be manipulated to maximize their contact with dirty air. As a result, fewer precious metals are required and the ability to minimize pollution is improved.

- Water Pollution

Planet Earth is comprised of 70% water, yet only the scarce percentage of 3% is fresh and available for our use. 1.1 billion people suffer from shortage of clean water every year and the condition of monumental water systems such as rivers, lakes and dams is aggravating. Due to the blistering consumption and exploitation of natural resources, it is expected that the ecosystem will continue to deteriorate.

The contribution of nanotechnology to this problem comes from nanoscale metal oxides, which serve as a low-cost, effective adsorbent for water remediation. Moreover, pollutants such as heavy metals could also be removed via magnetic nano-ferrofluid as an absorbent.

Oil spillage and introduction into waters also plays an important role in water pollution. While traditional methodologies for oil separation are usually expensive and lacking in efficiency, nanomaterials provide high separation efficiency, good recyclability, environmental friendliness and easy fabrication. In order to filter water, scientists have developed nanostructured membranes, which performed excellently for separation of oil from oil-contaminated water.

Several other methods based on nanotechnology have been used for water purification such as the utilization of magnetically active nanoparticles to extract chemicals from water and the breaking down of microplastics. The most notable one is the use of nano coagulants, though which scientists were able to mimic the structure of the Actina sea anemone. Except for the removal of larger particles, this novel invention can remove a broad spectrum of contaminants, especially small dissolved ones.

 [6]

Figure 3.6

- Land/Soil Pollution

Factors that mar the land include litter like paper, cans, glass jars, plastic products, and junked cars. Contaminants such oils, chemicals and ink are usually contained in the garbage scattered around the globe. Animals and plants are regularly at risk when coming in contact with it, mistakenly perceiving it as food. Soil erosion is one of the most significant problems of the modern times, with agriculture contributing to the loss of fertile land, pollution and sedimentation.

From conventional soil remediation methods arise several technical and economic challenges, such as effective blending and efficient interactions between the target pollutants

[6] *Nanotechnology*. d3i6fh83elv35t.cloudfront.net/static/2019/07/microplastics_2018-10-22T103113Z_1970773887_RC19A8FAA600_RTRMADP_3_FRANCE-POLLUTION-MICROPLASTICS-1024x658.jpg.

and remediation agents. Engineered nanomaterials (ENMs) are able to improve the aforementioned methods, by working on a small size, high specific surface area.

Again, the adsorption or immobilization process is one of the most effective and advantageous techniques involving nanotechnology. Such nanomaterials succeed in absorbing and immobilizing heavy metals from various media samples.

In order to break down harmful contaminants found in soil, nano-photocatalysts are used in convergence with an ultraviolet light source. The degradation rates achieved through this method are highly efficient, reaching up to 78% within five hours of treatment.

The Advantages-Opportunities of Nanotechnology

Nanotechnology provides a plethora of benefits regarding the environment, health, technology, and the economy. Such novel innovations could revolutionize many sectors of the industry:

- Environmental Benefits

Sensors and solutions are presently able to distinguish and detect chemical or organic agents within the air and soil with much higher affectability. Air filtration can be revolutionized with ion technology.

As mentioned above, nanotechnology has a lot of environmental benefits. The purification of water can be achieved and consequently the need for affordable, clean drinking water through rapid, low-cost detection could be met. Nanomaterials can be better adsorbents or catalysts that expel pollutants effortlessly and at a significantly lower cost than prevalent approaches.

Chemical reactions needed for soil cleansing are also more efficient and less polluting, with heavy metals and other contaminants being removed in environmentally-friendly ways.

Furthermore, nanotechnology provides for less burdening-for-the-environment approaches such as clean, affordable, and renewable energy sources. Nanostructured solar cells may be cheaper to fabricate and solar power simpler to install.

- Health Benefits

The treatment process of a disease could be accelerated, since the imaging and diagnostic tools enabled by nanotechnology could facilitate earlier diagnosis, more individualized treatment options and better therapeutic success rates.

Moreover, through nanotechnology, scientists are able to treat diseases in a more efficient way, by detecting and intervening in specific sequences of particles. Potential applications include the treatment of cancer and atherosclerosis among many other diseases and illnesses.

The impact of nanotechnology expands beyond research labs and hospitals and can be integrated into everyday life. Common products such as sunscreen, eyeglasses, and clothing fabrics can be drastically improved. The textile industry could be significantly assisted, since nanotechnology enables fabrics (or smart fabrics) to be more resistant, self-cleaning and antimicrobial.

Food life can be extended, food safety can be improved, consumers can be alerted that food is contaminated or spoiled, tears in packaging can be repaired, bacteria in packaging can be detected and stronger flavors and color quality can be produced. Nanotechnology holds a lot of promise in the food sector too with innovative concepts and ideas being constantly introduced.

The Disadvantages-Risks of Nanotechnology

The concentration and rapid growth of nanomaterials in nature could as well result to adverse effects for the environment, humans, economy and ethics.

- Environmental/Health Implications

Many severe risks could be imposed through the growth of nanotechnology. High doses of nanoparticles could result in lung diseases such as asbestosis, severe skin rashes due to allergic reactions and disruptions to important cell functions. Concerns about public health have been raised, since several nanomaterials have been reported to be toxic to humans, fish, and bacteria. The tiny size of such materials implies greater risk of uptake and interaction with sensitive organs.

Accidental releases of harmful chemicals during production, transportation, and disposal operations of nano-related products such as sunscreens, detergents, and cosmetics, could have a bad effect on the environment. Furthermore, backlash against relatively new and unknown technologies is expected to arise, concerning questions about the transportation, fate, reactivity, bioavailability, and toxicity of nanomaterials.

The potential environmental impacts of nanotechnology could mark the beginning of a new class of pollutants or Nanopollution. The waste that nanodevices or nanomaterials

generate (Nanowaste) could be extremely hazardous as it is generally unknown how the group of particles released into the environment will react.

Economic Benefits and Implications

Although this research report focuses on the environmental parameters of the topic, the integration of any new technology into a country's policies would affect other sectors as well, both positively and negatively. A strong economic sector, assisted by nanotechnology, would definitely benefit environmental and conservational efforts.

Economic growth generated by technology (Macroeconomics), is strongly lead by novel technological innovations such as those of the nanotechnology branch. Nanotechnology could have an important role in sustainable economic development. With investing in nanotechnology, the economy could be greatly benefited, since a lot of new job positions could be created and the collaboration between many sectors could be achieved.

It is expected that nanotechnology, like any other disruptive or enabling technology will have the destruction but also the creation of jobs as a result. Moreover, due to the efficiency of alternative energy sources reproduced with molecular manipulation, the side effect of economic market crashes related to a potential lower value of oil could emerge. Also, the cost of research and products made from nanoparticles is a controversial topic, since nanotechnology has not been fully introduced for mainstream use and the cost of nano-related products is relatively unknown.

MAJOR COUNTRIES AND ORGANISATIONS INVOLVED

United States of America

The United States of America is the leading country as far as nanotechnology patents are concerned and is also the home for the best Universities occupied with microbiology (Harvard University, Massachusetts Institute of Technology, University of California--San Francisco.)

In 2019, the United States Patent and Trademark Office (USPTO) saw more than 8,900 patents being filed. In 2013, President Barack Obama launched the Advanced Manufacturing Partnership[7], investing 2.9 billion dollars under the "Revitalize American Manufacturing Act".

[7] "Related Links." *MIT AMP 2.0*, web.mit.edu/pie/amp/.

As of 2021, President Biden's budget[8] requests over $1.7 billion for the NNI (National Nanotechnology Initiative).

China

China holds the spot as one the top five most-innovative-in-nanotechnology countries in 2019[9]. China has proven to be one of the most competitive countries in the field, constantly investing in medium and long-term scientific programs and ranking very high as far as scientific papers and patents are concerned.

Switzerland

Switzerland's high-tech, and mostly privatized economy makes it one of the wealthiest nations in the world. In collaboration with other countries (Japan, Austria, Germany) and the European Commission, Switzerland has financially supported R&D (Research & Development) for nanotechnology, with universities and companies about nanotechnology flourishing.

India

India holds an overall positive stance on novel technologies and fields of research. As they may be the catalyst to solving some of the country's most profound problems (the need for clean water, food, rapid, low cost diagnostic machinery, defense and anti-terrorism). The Department of Science and Technology in India invested $20 million between 2004 and 2009[10], they ranked third in patent publications in 2013 and also third in nano-related articles in 2019.

International Institute for Nanotechnology (IIN)

The IIN was founded in an effort to further boost nanotechnology R&D, uniting a plethora of engineers, chemists, biologists, physicians, and business experts. It has invested more than $1 billion dollars[11] in research, equipment and infrastructure, as well as assisted

[8] *NATIONAL NANOTECHNOLOGY INITIATIVE SUPPLEMENT TO THE PRESIDENT'S 2021 BUDGET* https://www.nano.gov/sites/default/files/NNI-FY21-Budget-Supplement.pdf PDF file

[9] "2019's 20 Leading Countries in Nanotechnology Publications." *STATNANO*, 8 Jan. 2020, statnano.com/news/67470/2019%E2%80%99s-20-Leading-Countries-in-Nanotechnology-Publications.

[10] "Natural Polymer Drug Delivery Systems." *Google*, Google, books.google.gr/books?id=_1IiDQAAQBAJ.

[11] "About." *International Institute for Nanotechnology*, 15 June 2021, www.iinano.org/about/.

many nanotechnology startup companies. Since 2000 it has collaborated with many countries and federal agencies and academic institutions.

Sustainable Nanotechnology Organization (SNO)

The mission of the SNO is to provide a professional society forum for the advancement of knowledge in all aspects of sustainable nanotechnology, including applications and possible repercussions. It similarly promotes cooperation between multiple fields of study and aims to promote the development of sustainable nanotechnology as well as the integration and utilization of nanotechnology concerning the environment, health, safety and policy and decision making.

American Society for Microbiology (ASM)

The ASM is one of the largest global life science organizations, with over 30,000 members who include researchers, educators, and health professionals. ASM's mission is "to promote and advance the microbial sciences."[12] ASM's meetings, publications, and books cover the whole field of microbiology, establishing linkages with the academic, regulatory, and industrial communities.

TIMELINE OF EVENTS

Date	Description of Event
1899	The American Society for Microbiology (initially named "Society of American Bacteriologists" was founded
1959-1989	Early stages of nanotechnology research
1986	The Foresight Institute was founded, which focuses on the development of nanotechnology and other emerging technologies.
1990s	Early nanotechnology companies began to operate, e.g., Nanophase Technologies in 1989, Helix Energy Solutions Group in 1990, Zyvex in 1997, Nano-Tex in 1998….
2000	The International Institute for Nanotechnology was founded

[12] "About ASM." *ASM.org*, asm.org/about-asm.

2006	The International Conference on Chemicals Management (ICCM), establishes the policy framework "Strategic Approach to International Chemicals Management" (SAICM)
2009 – 2010	The UNITAR and OECD, in collaboration with SAICM, hold three workshops about potential applications and risks of nanotechnologies and manufactured nanomaterials.
November 4, 2012	The first Sustainable Nanotechnology Organization conference was held
May 16, 2014	President Barack Obama launched the Advanced Manufacturing Partnership (AMP 2.0)
October 27, 2020	The U.S. National Nanotechnology Initiative published the "National Nanotechnology Initiative Supplement to the President's 2021 Budget"

UN INVOLVEMENT: RELEVANT RESOLUTIONS, TREATIES AND EVENTS

The Strategic Approach to International Chemicals Management (SAICM)[13]

In 2006, the International Conference on Chemicals Management (ICCM), established the policy framework "SAICM" to support the sustainable management of chemicals. SAICM promotes multi-stakeholder and multi-sector collaboration and strives for the achievement of the World Summit on Sustainable Development goal that, by 2020, chemicals are produced and used in ways that are not harmful for the environment and human health

Awareness-Raising Workshops on Nanotechnology/Manufactured Nanomaterials for Developing and Transition Countries[14]

[13] "Strategic Approach to International Chemicals Management." *UNITAR*, unitar.org/sustainable-development-goals/planet/our-portfolio/strategic-approach-international-chemicals-management.

[14] "UNITAR and OECD Launch Unprecedented Activities on Nanotechnology and Manufactured Nanomaterials for Developing and Transition Countries." *UNITAR*, unitar.org/about/news-stories/news/unitar-and-oecd-launch-unprecedented-activities-nanotechnology-and-manufactured-nanomaterials.

UNITAR and OECD, in collaboration with SAICM, held three workshops between 2009 and 2010 about potential applications and risks of nanotechnologies and manufactured nanomaterials as well as the opportunities for awareness-raising activities to be undertaken from those countries. Three similar workshops were held again in 2018.

The 10th International Nano-Authorities Dialogue[15]

In 2016 more than 50 representatives of ministries, agencies, research institutes and companies from German speaking countries (Austria, Germany, Liechtenstein, Luxembourg and Switzerland) discussed the future governance and regulation of nanotechnology.

Science and technology for development (Economic and Social Council)[16]

Between 2008 and 2009 the ECOSOC created a resolution where the need for education on science, technology, engineering and research for especially women particularly in the emerging technological fields such as nanotechnology was addressed (Article 2/ii/b). National Governments, the Commission on Science and Technology for Development and the United Nations Conference on Trade and Development were encouraged to embrace innovative technologies.

PREVIOUS ATTEMPTS TO SOLVE THE ISSUE

LEDCs and Microbiology/Nanotechnology

Progress is also visible regarding several LEDCs. Hospital intensive care units (ICUs) featuring modern medical technology, treatments, and interventions are being built by ministries of health. These units are seeing an increase in the number of infants and adults who are admitted and benefiting from them. Patients with chronic illnesses are increasingly

[15] "10th International Nano-Authorities Dialogue." *UNITAR*, unitar.org/sustainable-development-goals/planet/our-portfolio/nanotechnology/10th-international-nano-authorities-dialogue.
15

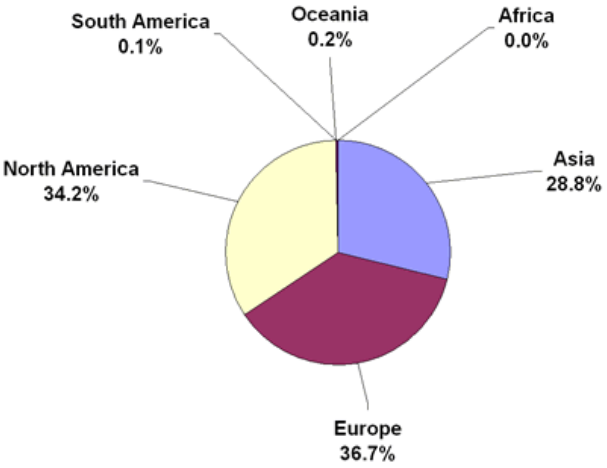
[16] The Economic and Social Council. *Science and technology for development.* 2008-2009. https://www.un.org/ecosoc/sites/www.un.org.ecosoc/files/documents/2009/resolution-2009-8.pdf PDF file

being treated in specialist units. Physicians are more aware about microbiology now than they were before, thanks to the Internet and increased exposure to the subject.

An increase in interest and involvement in nanotechnology by LEDCs has been observed. However, the main goals of LEDCs differ to those of other nanotechnology pioneers. LEDCs mostly utilize nanotechnology in order to "value-add" and not for sustainable development. Since the economy of such mostly relies heavily on agriculture, nanotechnology could help revolutionize farming with applications that could cut waste and make food safer. Issues challenging the global South like overcoming poor yields, malnutrition, disease and opposition to GMOs could be assisted by nanotechnology.

India, South Africa and Brazil among others have pursued investing in research on the aforementioned as a means of fortifying their economy and coping with pressing national matters. However, multiple concerns have been raised apropos the environmental, ethical and health-related consequences of these investments. Many LEDCs hold an unclear stance on whether investments on nanotechnology and microbiology should be made. This is mostly a consequence of a lack of education and poor public awareness or involvement on the matter. Some worries raised include the possibility of a technological divide, the loss of jobs, the exploitation of the South and the idea that other matters should be prioritized instead of the development of new technologies.

Nevertheless, LEDCs still do not have a strong standing on nanotechnology discussions compared to nanotechnology frontiers. During the 5th World Social Forum in Brazil, it was highlighted that international collaboration for nanotechnology would be hard to achieve since many believe that the voices of LEDCs will not be heard in global development. Thus, it is supported that even if collaboration were to occur, LEDCs would be left behind and the gap between them and industrialized countries would be aggravated. Similarly to other emerging technologies, this would lead to a technological divide (or nano-divide) where industrialized countries will benefit from nanotechnology and LEDCs will be exploited.



[17]

POSSIBLE SOLUTIONS

Public Awareness via Media

Public awareness is of paramount importance when shaping public opinion, which in turn affects the formation of government policies and business opportunities. In general, negative perceptions of nanomaterials and nanotechnology are an area of concern for the emerging global nanotechnology industry. Several institutions have already provided accurate safety-related data and are conducting research to assist the shaping of public opinion concerning nanotechnology. In this context, the role of the public's perception is very important for the development and growth of the industry in the short term. The debate on nanotechnology has led to a polarization of public opinion, with responses such as "messing with nature" and "playing God" being on the forefront.

In this case the media (television, radio, social media) plays a very important role and is proven to be very efficient in spreading awareness and establishing public opinion. Countries such as Germany are pursuing informing the citizens on nanotechnology and scientific progress in general. As a result, scientists are often seen on national television talking about their work and interacting directly with public to address concerns and answer questions. The public in general has a more well-rounded stance on the topic is more adequately informed. It is vital to debunk conspiracy theories concerning scientific progress, when the majority of the concerns raised is based on non-factual information.

[17] "Nanotechnology and LEDCs." *Https://Www.azonano.com/Images/Article_Images/ImageForArticle_1429_440633586165046 5958.Gif*.

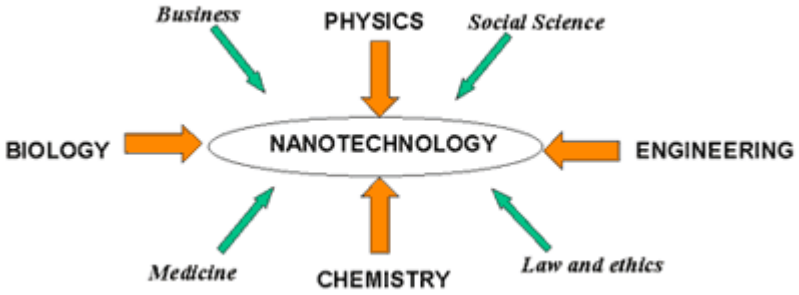
[17]

Workshops regarding Possibilities and Threats

It is vital that scientific communities in each country, as well as in unions actively host conferences and workshops about emerging technologies. Collaboration and discussion would enable the further development and knowledge about such technologies and would greatly contribute to a better dissemination of information on a global scale. Fields such as these of nanotechnology and microbiology are still growing and flourishing and the ways they would foster environmental solutions are still being discovered. Novel innovations made in the scientific world can drastically benefit everyday life in a plethora of ways. Deliberation on the possibilities of the aforementioned technologies would lead to a more sustainable future. This would also affect each country's policy making because they would acknowledge the various benefits the integration of new technologies would have.

Seminars focusing on the possible adverse effects of these technologies would also be extremely valuable. Nanotechnology and microbiology remain relatively new fields of study and their threats and prevention methods are still being discussed. Conferences about the regulation of nanomaterials and their future implications play a significant role. What is more important however, is that such councils should be prioritized and thus held regularly to ensure the development and expansion of these technologies. Conducting these seminars would result into the signing of important treaties and resolutions, which are very influential for the future policies of the countries involved.

The involvement of intergovernmental or non-governmental organizations would also work in favor of the evolution of the previously mentioned technologies. There is a multitude of organizations devoted to R&D for nanotechnology and microbiology, all of which could significantly contribute to raising awareness and informing about technological developments.



[18]

[18] *Nanotechnology*. https://www.dit.ie/nanotech/media/ditnanotech/images/nanof.gif .

Figure 5.14

Education

Nanotechnology research and development takes place all over the world. Students who are exposed to such trends early on will be more informed about job options and will have ideas about how to collaborate in teams across disciplines and cultures. Students studying nanoscience and nanotechnology can already benefit from an increasing number of international collaborations.

For many, nanoscience and nanotechnology are associated with working in a lab conducting scientific research. While this practice is widespread, generalizations about it are inaccurate. Nanotechnology can be pursued in a variety of methods, ranging from formal education and hands-on training to entrepreneurship and manufacturing.

A strength of the nanoscience and nanotechnology communities is the collaboration aspect. With early exposure to such technologies, students are able to communicate across professions, examine and discover each other's perspectives and address the most pressing concerns in a variety of fields. Inventing new tools, materials, methodologies, and possibilities as a field and educating students about this facet of new technologies will have a meaningful impact.

R&D Funding

Currently most of the emphasis is put on military power, with governments like the one of the U.S. investing billions of dollars on R&D for military purposes. It should be noted that many efforts are being made worldwide to increase governmental, as well as public funding for breakthrough technologies. A lot of research centers focus on developing these technologies, but also frameworks such as the Framework Programme 6 (FP6), which aims to produce innovative technologies that directly benefit the EU, either economically or socially, assist their growth. Nanotechnology and microbiology could play a monumental role in saving the planet, thus their funding should be prioritized.

Collaborative Regulation

Currently, regulatory bodies in the United States and the European Union have concluded that nanoparticles call for a whole new risk assessment approach and that a thorough risk analysis is required.

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Collaboration in the oversight and regulation of nanotechnology and nanomedicines has the potential to be extremely beneficial. According to this approach, during the whole product life cycle, including pre- and post-market phases, academics, industry, and regulators would be integrated. This life-cycle approach to medical product regulation necessitates global collaboration on nanosafety and nanotechnology regulation. Establishing institutional frameworks for worldwide cooperation set of specific aims and timelines would highlight concerns and developing science issues that could aid future field developments and be important to future regulatory considerations.

Possible agencies, committees and organizations involved include: the European Medicines Agency (EMEA) the FDA, the European Committee for Standardization (CEN), the International Organization for Standardization (ISO), the Organization of Economic Co-operation and Development (OECD), the International Conference on Harmonization of Technical Requirements for Registration of Pharmaceuticals for Human Use (ICH)

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