

CNS-UCSB mini case studies for classrooms and informal education

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Introduction

These mini case studies are realistic situations based on published research about nanotechnologies and their implications for society, current as of 2010. They mirror some of the research themes CNS-UCSB is investigating on nano and other emerging technologies – risk and risk perception, the global economy, environmental implications, and the process of research, development, and commercialization of these technologies.

We hope instructors from middle school level and higher, in science classes, humanities classes and social studies will use these case studies to complement other material and instruction, such as learning about nanotechnologies, or learning to think critically about choices we make as individuals and the potential impacts of those choices on others. The cases assume a basic level of understanding about nanotechnology (see below).

Each mini case study includes a Teacher Guide that outlines the major themes and discussion points, and suggests how to use the case in a classroom or group setting. There are no right or wrong answers in discussing the case; the point is to get students thinking about many different points of view and to practice critical thinking and evaluation skills that they can go on to apply in their own lives. The greater the variety of ideas and opinions that participants voice during the activity, the better and more thought-provoking the exercise will be.

To provide more information about the technologies and issues featured in the cases, we have compiled a set of resources and links on the CNS Education website: www.cns.ucsb/education. This is not an exhaustive list, and you will find more by searching the Internet and YouTube for specific topics.

We would love to hear any feedback, positive experiences or constructive suggestions that will help us improve the cases and create new ones.

About CNS-UCSB

The Center for Nanotechnology in Society at UC Santa Barbara is an NSF-funded research center investigating a range of societal implications of nano and other emerging technologies since 2006. Scholars from social sciences, humanities, and nanoscale science and engineering conduct collaborative, interdisciplinary research on: the historical context of nanotechnology; innovation and tech transfer processes; risk perception and the public sphere; and technology diffusion and globalization. CNS research helps policy makers, scientists and engineers, industry, community organizations, and the general public understand the opportunities and risks that nanotechnology affords. For more information, please visit our website: www.cns.ucsb.edu.

Basic level of understanding about nano

Before discussing these cases, we recommend that instructors give students a basic understanding about nanotechnology. What does a basic understanding entail? I like to

emphasize three key need-to-knows about nano:

1) Scale: what 'nanoscale' means, and the commonly-used definition of nanoparticles as being between 1-100 nm in size.

2) Things 'get wacky' at the nanoscale: Materials exhibit novel properties at the nanoscale, often different from their bulk counterparts.

3) Control of matter: this is the 'technology' part of nanotech, since nanoparticles have always existed in nature, but only recently have we been able to control, manipulate and engineer particles at the nanoscale.

These are the most fundamental and significant characteristics of nanotechnology, but of course there is a whole lot more to know and learn when it comes to nano. For more information on nanotechnology basics, including links to educational material for all ages, please visit the CNS-UCSB Education website, cns.ucsb.edu/education.

Mini Case Study: The new and improved tennis racket



Your friend tells you about this amazing new tennis racket.

“You HAVE to have it! It’s super strong and really lightweight, because it’s made with carbon nanotubes. Plus, the Big Retail Store is selling them at a very low price!”

“How can it be such a low price if it’s new technology?” you ask. You’re excited, because even though you don’t really need a new racket, you would love to have a new one.

“I dunno - maybe because of where it’s made,” your friend replies. “Many companies have their products made in other countries, where wages are lower, because it’s cheaper than making them here. That makes the products cheaper for us to buy.”

That afternoon, you’re surfing the internet to find out what carbon nanotubes are. You see an article¹ that says that because of the size and shape of these types of nanoparticles, inhaling carbon nanotubes may have similar effects as asbestos, a material that was banned in the 1970s and 80s, – the lungs have difficulty clearing out asbestos particles, often resulting in a certain type of lung cancer. You also read that when carbon nanotubes are embedded in the tennis racket material there is no danger of inhaling particles – so using the racket is safe.

You search for more information about inhaling nanoparticles, and find a scientific study² that linked the illnesses and deaths of factory workers to plastic nanoparticle inhalation from paint. The ventilation system in the factory was broken, and the workers had no safety training or safety equipment for working with nanoparticles. They were not using carbon nanotubes or making tennis rackets, but it makes you wonder about the conditions in the factory where they ARE making the rackets with carbon nanotubes.

What are the issues here? Do you buy the nano tennis racket? What would you consider in making this decision? Is there other information you would want to know?

¹Ryman-Rasmussen, Jessica P. et al. (2009). Inhaled carbon nanotubes reach the subpleural tissue in mice. *Nature Nanotechnology* 4, 747 - 751

²Song, Y., X. Li and X. Du (2009) Exposure to nanoparticles is related to pleural effusion, pulmonary fibrosis and granuloma. *European Respiratory Journal*; 34:559-567

To find out more about carbon nanotubes and other technologies in our lives, visit www.cns.ucsb.edu/education

TEACHER GUIDE

Mini Case Study: The new and improved tennis racket



What are the issues here? Do you buy the nano tennis racket? What would you consider in making this decision? Is there other information you would want to know?

The **themes** in this scenario include:

- *Globalization, global economy* – that people and companies around the world are involved in the products we buy and use. All the stages of product creation may happen in different countries: from research and design, to manufacture, to where the product is sold and used, and finally discarded or recycled. The Head tennis racket in the image is made in China.
- *Risk and equity issues* – what are the risks associated with the technology or product, at each stage of a product's life cycle, and who is at risk? Are those at risk the same as those who benefit from the product, or not?
- *Environmental health and safety* - are workers manufacturing the product protected, do they have safety training and protective gear for working with nanoparticles? As of 2010 the use of nanomaterials by companies is not monitored or regulated by any agency. (For a clearly-written discussion of regulation issues, see article [Nanotechnology Regulation: Policies Proposed by Three Organizations for the Reform of the Toxic Substances Control Act](#) by Anna Lamprou for the Chemical Heritage Foundation. Another resource is NIOSH <http://www.cdc.gov/niosh/topics/nanotech/>)
- *Carbon nanotube technology* – one way carbon nanotubes are being used is in sports equipment and other products to add strength to the materials without adding weight. CNTs are sheets of carbon atoms rolled into a cylindrical shape, and this structure makes them very strong and lightweight.

Student Activity

Working in small groups or as a whole class, students read the scenario and discuss the issues and options. Try to get as many ideas and thoughts on the topic as possible – there are no wrong answers.

One way to think about this scenario is, who benefits? What are the risks, and to whom? Which is greater, the benefit or the risk? Is there any other info you would want to know before making a decision?

Below are some of the benefits, risks, and info that we've identified. Your students may think of others:

Who benefits if you buy the racket?

- **You** get a new racket, your tennis game may improve.
- **The company** makes money from you buying their racket, and all the people and companies around the world involved with that product.
- **Someone else** can use your old racket – maybe you give it away.

What are the risks of buying the racket, and to whom?

- Little risk to **you** as the user of the racket (the carbon nanotubes are embedded).
- The factory conditions may be dangerous for **workers**, but you're not sure.
- **You** may feel bad if buying the racket supports dangerous factory conditions, or a factory that pays very low wages to workers.
- Risk to the **environment**: materials and energy resources to make the new racket, package it and ship it; the landfill if you throw your old racket away in the trash.

What other information do you want to know before making your decision? (Follow up question: is the info available, or will you have to make your decision without it?)

- You may want to know about the factory conditions, especially if workers are exposed to carbon nanotubes in dangerous ways.
- You may want to know what the cost is in resources for a new racket – raw materials, energy to make it and ship it, etc.

To find out more about nanotechnology and these issues, visit www.cns.ucsb.edu/education

This mini case study was created by Julie Dillemoth, UCSB Center for Nanotechnology in Society (CNS-UCSB).
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Mini Case Study: Sunscreen at the beach



You and your friends are at the beach, passing around a bottle of sunscreen. Your friend Jamie is explaining that the reason that the white sunscreen goes on clear is that the *titanium dioxide*, the material that physically blocks the sun, is in nanoparticle form, so small that the particles don't reflect visible light - they become invisible.

“In fact, the nanoparticles are actually smaller than your skin cells,” Jamie says. “But don't worry – studies¹ show that the nanoparticles don't go through your skin, they stay on the surface, as long as you don't have a cut or something,” Jamie pauses thoughtfully. “I guess you could accidentally ingest them though, like if you used your hands to eat after applying sunscreen.”

“I don't see anything on the bottle that talks about nanoparticles,” you say, looking at the label.

“That's because the manufacturers don't have to put anything on the label. There are no regulations about using this nanotechnology in consumer products, no rules about labeling products,” Jamie replies.

You look along the beach and in the water and notice how many people there are – it's a really hot day, and it seems like everyone in town is at the beach. You wonder how many people are wearing sunscreen with nanoparticles. You also imagine it washing off each person's skin in the ocean, or at home in the shower.

“What happens to these nanoparticles in the environment?” you ask Jamie. You remember hearing news stories about different chemicals and pollutants getting into fish, and interfering with the ecosystem in different ways. You wonder about nanoparticles, which can be smaller than cells. Jamie shrugs, “I'm not sure, I think scientists are still doing research on that.”

What do you think about the sunscreen you just put on your skin? What are the benefits and risks, to you and to others (including the environment)? Will you use the sunscreen again? Are there alternatives to using this sunscreen?

¹The Environmental Working Group's 2009 Sunscreen Investigation (<http://www.ewg.org/cosmetics/report/sunscreen09/investigation/Nanotechnology-Sunscreens>) summarized 16 peer-reviewed publications on skin penetration.

To find out more about nano in sunscreen and other technologies in our lives, visit www.cns.ucsb.edu/education

TEACHER GUIDE

Mini Case Study: Sunscreen at the beach



What do you think about the sunscreen you just put on your skin? What are the benefits and risks, to you and to others (including the environment)? Will you use the sunscreen again? Are there alternatives to using this sunscreen?

The **themes** in this scenario include:

- *Risk assessment and risk versus benefit issues* – what are the risks associated with the technology or product, at each stage of a product’s life cycle, and who/what may be at risk? Are those at risk the same as those who benefit from the product, or not? How do the benefits of using the product compare to the risk? Are there alternatives?
- *Regulation and labeling* – who is, or should be, responsible for protecting consumers? What information about a product should consumers have a right to know? What assumptions do you as a consumer make when you buy something at the store? As of 2010, there are no regulations around labeling nanoparticles in products, even though there are over a thousand products that contain nanoscale particles. Visit www.cns.ucsb.edu/education for more info.
- *Titanium dioxide and Zinc oxide nanoparticles* – these metal oxides traditionally used to physically block the sun reflect light and are visibly white on the skin. At the micro and nanoscale, the particles are too small to reflect visible light, so they ‘go on clear’, while still blocking UV rays.

Student Activity

Working in small groups or as a whole class, students read the scenario and discuss the issues and options. Try to get as many ideas and thoughts on the topic as possible – there are no wrong answers.

The two big themes here are risk issues and product regulation/labeling – and they are big. The goal is to start students *identifying* and *thinking about* these issues, taking a more critical look at products they may use every day.

Below are some of the benefits, risks, and info that we’ve identified. Your students may think of others:

Who benefits if you use the sunscreen?

- **You** protect your skin from sunburn.
- **The company** (and all the people and companies involved with that product) makes money from you buying their sunscreen.

What are the risks, potential risks, and unknown risks, of using nano sunscreen, and to whom?

- Potential or unknown risk to **you** if nanoparticles enter your body, through damaged/cut skin, ingestion or inhaling. (For example you might ingest the sunscreen if you apply it with your hands, then pick up food, lick your fingers, etc.)
- As-yet-unknown risks to the **environment** and **ecosystem** when the sunscreen washes off in the ocean or in the shower.

What are the issues or concerns around labeling and regulation?

- Since labeling of nanoscale particles is not required, you do not necessarily know whether a sunscreen you buy/use has nanoparticles in it.
- How much do you trust a company to sell safe personal care products? (and what do you mean by ‘safe’?)
- How can you find out more about the ingredients in a product?

What other information do you want to know before making your decision? (Follow up question: is the info available, or will you have to make your decision without it?)

- Are titanium dioxide or zinc oxide nanoparticles harmful to the human body? (this info is not available; current research underway. Note that macro-scale titanium dioxide is safe to ingest, however, and can be found in some powdered donuts and some milk and ice creams to enhance the white color)
- Are titanium dioxide or zinc oxide nanoparticles harmful to the environment, or other organisms? (this info is not available; current research underway)
- Are there ways to minimize the risks? (for example, using less sunscreen)
- Do water treatment plants deal with nanoparticles, after they go down your shower drain?
- What are alternatives to nano sunscreen? (for example, sunscreens without nanoparticles (follow-up question: how do sunscreens without titanium or zinc oxides block UV rays?), wearing a hat/clothing and not applying sunscreen at all)

To find out more about nanotechnology and these issues, visit www.cns.ucsb.edu/education
For a hands-on activity about nanoparticle sunscreen, visit NISE Net, nisenet.org

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