

Exploring Nano & Society—Invisibility Cloak

Try this!

Look in the plastic cups. What do you see?



What's going on?

The glass rod appears to disappear in one of the cups, but not the other.

One cup is filled with baby oil, while the other is filled with plain water. The rod can be hidden in the oil because it's made of borosilicate glass, which has a similar *refractive index* to baby oil. It can't be hidden in the water, because borosilicate glass has a different refractive index from water.

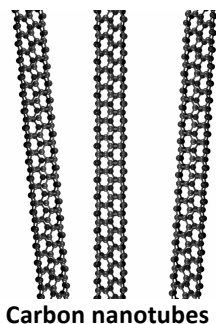
The refractive index indicates how fast light can travel through a material. The higher a material's refractive index, the slower light travels in that material. If two materials have a different refractive index, the speed of the light changes as it moves from one material to the other. This causes some of the light to *reflect*, or bounce off an object, and some of it to *refract*, or bend as it goes through an object.

You can't see the colorless object in the oil, because light traveling from baby oil to glass doesn't change speed very much. It doesn't refract or reflect when it hits the glass, so we don't see the object. It's almost invisible!



In everyday life, you see refraction at work when a straw submerged in a glass of water appears to bend. The light interacts differently with the air outside the glass than the water inside the glass, creating the illusion that the straw is bent.

How is this nano?



The way a material behaves on the macroscale is affected by its structure on the nanoscale. Using nanotechnology, it is possible to engineer new materials that can interact with light in special ways.

Engineers have created special coatings that control reflection and refraction, improving the energy efficiency of windows and making better solar cells. Researchers are even experimenting with ways of bending light to cloak objects—making them invisible to the human eye or to surveillance devices. For example, scientists at the University of Texas at Dallas have created a transparent curtain made out of millions of carbon nanotubes, which can hide objects underwater.

Think about it...

1. What would you do if you had an invisibility cloak? What do you think other people might do?
2. Would you make rules for how people could use invisibility cloaks?

Technologies and society influence each other. When we use a new technology—whether it's a cell phone or an invisibility cloak—we create new ways of interacting with each other. We work together to figure out when, where, and how it's ok to use the new technology. Eventually, we create norms, rules, and laws that influence how we use it. New nanotechnologies will affect our social relationships, just like any other technology does.

Learning objectives

1. The way a material behaves on the macroscale is affected by its structure on the nanoscale.
2. Technologies and society influence each other.

Materials

- Plastic cups (2)
- Baby oil
- Water
- Borosilicate glass stir rods (2)
- “Nanotechnology Mirage” sheet

Borosilicate glass stir rods are available from scientific suppliers, such as www.sciencelab.com (#22-1900-6-DZ).

Notes to the presenter

SAFETY: Visitors should be careful handling the glass objects. Visitors should not ingest the liquids. Visitors should be supervised at all times while doing this activity.

Before doing this activity, fill one cup with baby oil and one cup with water.

Check the lighting in your demonstration space. In some places the “invisible” object will be apparent because of the placement of the lights. If this happens, try a different spot.

This activity is based on a demonstration about the refraction of light, but it provides an opportunity to engage visitors in conversation. The activity can spark visitors’ imagination, creating an opening for them to think about the potential for an invisibility cloak.

Visitors may ask what the difference is between invisibility and “stealth.” On explanation is that it depends on what an object is “invisible” to—the human eye, or other means of observation such as radar.

Related educational resources

The NISE Network online catalog (www.nisenet.org/catalog) contains additional resources to introduce visitors to the relationship between nanotechnology and society:

- Public programs include *Flying Cars, Nanotech and Consumer Products, Shrinking Robots!*, and *Would You Buy That?*
- NanoDays activities include *Exploring Nano & Society—Space Elevator*.
- Forums include *Energy Challenges, Nanotech Solutions?, Nanomedicine in Healthcare, Privacy—Civil Liberties—Nanotechnology*, and *Risks, Benefits, and Who Decides?*
- Media include *Does Every Silver Lining Have a Cloud?, Is that Robot Real?, Let’s Talk About It, Same Sides, Societal and Ethical Implications Posters*, and *Wonders and Worries of Nanotechnology*.
- Exhibits include *Balance our Nano Future* and *Nanotechnology: Fact or Fiction?*

Credits and rights

This activity was created as a collaboration of the NISE Network and the Center for Nanotechnology in Society at Arizona State University.

Images of nanotechnology “mirage” courtesy Ali Aliev, Alan G. MacDiarmid NanoTech Institute, University of Texas at Dallas.



This project was supported by the National Science Foundation under Award No. 0940143 and 0937591. Any opinions, findings, and conclusions or recommendations expressed in this program are those of the author and do not necessarily reflect the views of the Foundation.

Copyright 2012, Sciencenter, Ithaca, NY. Published under a Creative Commons Attribution-Noncommercial-ShareAlike license: <http://creativecommons.org/licenses/by-nc-sa/3.0>