Lessons from Mother Nature

by Alan Smith

In an earlier article (Jan-Feb 2006 CI, p. 8), the author asked "Does Nanotechnology Have a Sporting Chance?" and reviewed briefly the hype surrounding the field. In this article, Smith illustrates how lessons from Mother Nature are resulting in the design of new nanotechnology applications. These applications, which relate to our everyday life, provide excellent examples that children and adults can relate to, and should be used to promote good science.

Sunset over the Grenadines (Caribbean)—Palm Island. *Photo credit: Alan Smith*

Over the last hundred years Nobel Prizes have been awarded in medicine, chemistry, and physics for work that would nowadays be described as nanotechnology. Nanotechnology is certainly not new; Mother Nature has been the best exponent since creation!

For those not familiar with the nanoscale, it is about as small as you can get, and down at that molecular or atomic level it has been found that properties of things can change. To help understand how small the nanoscale is, it would take 80 000 nanoparticles in a row to be just the diameter of a human hair, and if a gull landed on the deck of an aircraft carrier the ship would sink in the water by only one nanometre (a millionth of a millimetre).

Although scientists are developing exciting new products that make use of the new properties offered by nanotechnology, nature has been the leader in this science. Geckos hang upside down on the ceiling because of nanoscale "hairs" on each toe. Each "hair" grips with a miniscule force, but when there are millions of these "hairs" on each toe it is able to support its own weight when it is upside down. In fact, if it was 200 times its own weight it would still be able to hang there. Industry is looking at copying this ability by developing more-effective adhesives.

There is a beetle that lives in the scorching heat of the Namibian Desert that gets its water through nanotechnology. Its back has a surface which repels water, but some bumps on its shell do not have this special surface. In the early mornings the water in the atmosphere condenses on those bumps and when the drop gets large enough it runs down the water repellent surface straight into the beetle's mouth. Such "hydrophobic" surfaces are now being used in textile applications; Hugo Boss sells suits that have self-clean surfaces based on nanotechnology coatings. Similar effects are being used by Gortex for wind and waterproofing. It is known as the lotus effect, since water just runs off lotus leaves.

Moths' eyes are antiglare and antireflective; if they were not then their predators would be able to pick them off much more easily. Scientists have copied the nanotechnology structure of those eyes and are able to produce antiglare and antireflective films, which could lead to digital camera screens that consumers can see on sunny days.

Many color effects in nature are the result of nanotechnology. The colors in butterfly wings or the pearl effects of shells are due to light being bounced off nanoscale layers in the structure of the wing or shell. Christian Dior has copied this effect with their Pure Poison perfume bottle, which looks like a pearl due to nano-layers on the inside of the bottle. Dior was not the first to produce nanotechnology color effects, the Romans left behind a glass cup known as Lycurgus' cup. Estimated to be 1600 years old, this piece in the British Museum looks jade green in natural light

but when a bright light shines through it, it becomes a spectacular red color. This is because of a minute amount of nanoparticles of gold and silver in the glass that reflect light in a novel way. The effect is similar to the reds and yellows one sees at sunsets, where the light bounces off nanoparticulates in the atmosphere. After Krakatoa exploded in 1883, there where incredible sunsets for decades, all due to nanoparticles.

Many sunscreen products use nanoparticles to bounce off the bad ultraviolet light and let through the good, tanning UV light. Each year, 1 300 people in Australia die from skin cancer, so there should be some benefit from this nanotechnology.

Our own skeletons are self-assembling nanostructures. Again, scientists are copying such structures to make new materials that are stronger and lighter weight. These new nanocomposite materials are finding applications in many cars now, where replacement of heavy metal parts with these strong and lighter-weight materials, enables more miles per gallon. Ford, General Motors, BMW, and others are all reducing the weight of their car models. In addition, Mercedes has developed an antiscratch surface for its cars that is based on nanotechnology. Sporting goods manufacturers are also making use of nanotechnology structures to obtain different properties. Roger Federer's tennis racquet, Easton baseball bats, and Padraig Harrington's golf clubs are made from nanocomposite materials.

It is estimated that there are already over 700 "nano"-based products on the market. So, it is no wonder that governments worldwide are investing heavily in this technology. It has been said that if developed countries are not involved in nanotechnology, they will become third-world nations very quickly. The timescales for taking ideas through research to production are shorter now than they have ever been. Nanotechnology is particularly multidisciplinary and the speed at which products are being introduced exceeds most previous developments.

In addition to the energy saved by reducing the weight of cars, there are other applications that are beneficial to mankind. The UK company Oxonica has developed an additive based on cerium oxide nanoparticles that is added to diesel fuel at less than 5 parts per million. The ingredient helps catalyze the "burn" better; improving mileage by up to 15 percent and reducing polluting exhaust fumes.

At the nanoscale, it is possible to detect things faster and more sensitively; a sniffer dog can find a human after an earthquake or a trace of a drug in someone's luggage because it is working down at the molecular level. A great deal of research is being conducted to detect diseases using nanotechnology before they get a hold in the body. In this regard, the U.S. government is investing heavily in its Cancer Nanotechnology Plan. In terms of healthcare we are only seeing the tip of the iceberg.

Following the SARS outbreaks in the Far East, silver nanoparticles, which are commonly incorporated into wound dressings because of their antimicrobial properties, are now being used in other applications. Washing machines and refrigerators have been developed that use this technology to prevent mold. There are baby milk cartons, socks, and even underpants that use silver nanoparticles to reduce the possibility of infection.

The University of Leeds has a group of researchers using nanotechnology to develop nanofluids. By suspending nanoparticles in water or other liquids, these nanofluids can transfer heat up to 400 percent faster than other liquids. In a central heating system, nanofluids could increase efficiency without the need for a more powerful pump, thereby saving energy and providing major environmental benefits. Some researchers have theorized that nanofluids could be used during critical surgery to cool the brain so it requires less oxygen, thereby enhancing the patient's chance of survival and reducing the risk of brain damage. The technology could also be used to produce a higher temperature around tumors to kill cancerous cells without affecting nearby healthy cells.

We still have a lot to learn about nanotechnology from Mother Nature!

I'll bet there is a creature somewhere that developed this technology long before the University of Leeds team applied it. We still have a lot to learn about nanotechnology from Mother Nature!

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