

HEALTH AND STRESS

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WHY MORE GOOD THINGS WILL BE COMING IN SMALLER PACKAGES

KEYWORDS: Brain Shower Technology for stress, carbon nanotubes, "electronic nose", pursonic surround sound, self-cleaning bathrooms, artificial bone, substitute skin, Clinton Syndrome, femtosecond lasers, dendrimers, PEBBLES, nanobombs, UV Pearls, buckyballs, Type A bathrooms, Oswald Spengler and *The Decline of the West*

Most of us have grown up in a culture where bigger is almost always assumed to be better. Accolades are awarded to architects who design the world's tallest buildings or longest bridges. There are prizes for the largest watermelon, pumpkin and almost any fruit or vegetable that can be grown - as well as for the biggest trout, tiger or other wild animal that has been caught or killed. The *Guinness Book of World Records* is replete with all sorts of bizarre records testifying to the belief that "bigger is better".

Over the past few decades there has been a trend in the opposite direction. Big and bulky boom boxes have been replaced by Apple iPods, which made their debut in 2001, could play 1000 songs and cost \$399. These have also become progressively smaller and less expensive despite increased capacity and additional features. The iPod mini introduced two years ago was almost half the size of the original and although wildly popular, was replaced last year by the iPod nano. The nano is the size of 5 credit cards stacked together, weighs only 1.5 ounces and is 62% smaller in volume than the mini. And while the first iPods could only play music, later versions can hold e-books and display photos and videos in color. The iPod nano also allows to you play solitaire and other games, make shopping lists, listen to your favorite podcast, transfer an address book and calendar from your PC, has a stop watch to time running and exercise activities, a clock to set time in cities around the world and an alarm for each time zone.

In one test of the \$249 iPod nano, *The Wall Street Journal's* Walter Mossberg "loaded the entire 16-hour unabridged audio version of *The Da Vinci Code* and still had room

left over for 1,128 songs, plus my 24 photos, a couple of podcast episodes and about 50 contacts copied from my computer's address book." The rechargeable battery lasted over 14 hours and all iPods produce superb sound using a cassette player or car's music system. Smaller capacity \$199 and even the latest \$99 iPod nano should satisfy most needs.

ALSO INCLUDED IN THIS ISSUE

- Richard Feynman, Nano Nonsense & "There's Plenty of Room at the Bottom"
- Nano Breakthroughs In Diagnosing, Treating And Preventing Disease
- What Are The Drawbacks, Deficiencies Or Dangers Of Nanomania?

But **why did Apple decide to call this the iPod nano?** Mini or micro are readily understandable prefixes and suffixes to describe something that is small, or smaller, but nano would likely mean little to many people. This was a brilliant move, since **nano this or nano that will soon be household words because of exciting nanotechnologic advances that promise to have a profound influence on our daily lives.**



Apple hardly has a monopoly on this miniaturization trend and there are even smaller and less expensive MP3 devices with additional features. The mauve mobiBLU shown on the left next to a quarter is tinier than a 1" cube and in addition to holding hundreds of songs, it has a voice recorder, clock, calendar sleep timer and an FM receiver that allows you to record as well as listen to programming with stereo output. The battery is good for 8-10 hours on a single charge and as shown in the enlarged illustration in the middle, a blue light emitting diode display a sharp, bright and easy to read display. It is available at Walmart and elsewhere for under \$100 with models having more content slightly higher. The X-8 shown on the right is 1.5 X 1.6 X .5 inches, and although half as thick as the mobiBLU, has similar features as well as a very clear 1.2 inch color screen. There are dozens of others, some of which are designed to reduce stress.



The LG FM-20 Stress Relieving MP3 players shown to the left look more like Christmas ornaments. They come in shiny colors with a screen that appears out of its shell when it is turned on. It can store 1000 songs, has a 20-hour battery life, FM tuner, and features "Brain Shower Technology" to relieve stress by sounds and patterns that produce a sense of deep relaxation. A special SPA program can also provide music to reduce stress and promote sleep

Cell phones are another example of how progressive miniaturization can occur despite the addition of numerous other features. Just compare the bulky luggable rather than portable cell phones available two decades ago with today's sleek attractive devices that easily fit in a shirt pocket and also let you play games, watch videos and take pictures. Some cell phones are replacing MP3 players as more models now not only store songs but also audio files like e-books and podcasts. Bluetooth enabled phones could soon make these obsolete since they can also access the Internet and some have cameras, up to an hour of video recording and capabilities and still weigh less than 3 ounces.



Nanotechnology now allows all of these features to be combined and incorporated into clothing. The black jacket to the left has electronic fibers imbedded in the right sleeve that can control an iPod by simply pressing on various commands that turn it on and off, access different selections, pause, fast forward and other functions. The red jacket in the middle has a built in MP3 player, Bluetooth cell phone and rechargeable battery. Special fibers sewn into the jacket conduct electrical signals that link the module to headphones and a microphone embedded in the jacket's collar and to a command center keyboard sewn into the left sleeve. If you are listening to an MP3 player when you receive a call the music will be automatically paused and the call routed through the wireless Bluetooth hood speakers. The command center has a display that lets you check your caller ID as well as one-touch controls to perform all MP3 player and phone functions. Lighter garments and protective helmets such as the one on the right with similar features were popular at last month's Winter Olympics. Shaun White used an iPod equipped helmet during his Gold medal performance and all the uniforms of the award winning U.S. snowboard team were wired for MP3 players and had iPod-size pockets, hood speakers and a control panel on the left sleeve.

What has any of the above to do with stress or health? And exactly what is nanotechnology and why will it have such dramatic effects on our daily lives? After all, nanotechnology has been around for over fifty years so why all the sudden fuss? If only some of the lengthy list of potential medical applications result in millions of people living much longer what will the effect be on our health care system and economy? How can we be sure that this new technology is entirely safe and does not pose environmental threats? Those are some of the questions and issues we would like to address in this Newsletter. In addition, as will be seen, some nano advances that are designed to make life less stressful could easily boomerang and have the reverse effect.

Richard Feynman, Nano Nonsense & "There's Plenty of Room at the Bottom"

Nano means a billionth and is derived from *nanos*, the Greek word for dwarf. A nanometer is a billionth of a meter or a million times smaller than a millimeter. Most nanotechnology research is in the range of one to several hundred nanometers. To put this in perspective, a carbon atom is 1 nanometer wide, a hemoglobin molecule is 4 nanometers and viruses are around 100 nanometers, compared to a red blood cell, which is over 2,000 nanometers long. Nanotechnology focuses on the ability to build or manipulate structures molecule by molecule to produce endless possibilities. As noted in a recent article, this will "allow scientists to create new structural materials 50 times stronger than steel of the same weight, making possible the construction of a Cadillac weighing 100 pounds." An Israeli firm has already developed nanotechnology-based material that is five times stronger than steel and twice as strong as any impact-resistant material used in protective gear. It has withstood tests during which it was subjected to a steel projectile traveling at speeds up to 1.5 kilometers/second or 3400 miles/hour. This impact would be the equivalent of dropping four diesel locomotives on an area the size of a human fingernail. Full-scale production of several tons of material daily is expected within six months.

The birth of nanotechnology can be credited to Richard Feynman, who received a Nobel Prize in 1965 for his major contributions to quantum computing and an area of physics known as quantum electrodynamics. Some of his other scientific accomplishments included being part of the Los Alamos team that developed the first atomic bomb and solving the problem of the 1986 Challenger space shuttle disaster by simply demonstrating how the rocket booster's O-rings lost all their resiliency in ice water. Feynman was widely known for his insatiable curiosity, sense of humor and extreme honesty. Always a playful practical joker who was not intimidated by authority, he caused consternation during the years he helped develop the atomic bomb, by figuring out in his spare time how to pick the locks on filing cabinets and crack the safes that contained classified information. Without removing anything, he left taunting anonymous notes to let officials know that their security system had been breached. This and several similar escapades illustrating his playful temperament may explain why his early proposals were not taken seriously.

Feynman had suggested over 50 years ago that it should be possible to manipulate atoms and molecules to produce things so minute and marvelous that they were practically inconceivable. One was an army of remote controlled miniscule mechanical surgical robots that could make repairs on a molecular level. Another was his contention that the contents of all the books in any large university library could easily fit on part of a post card and readily retrieved using nanotechnology. Indeed, all the books in the world in every language would fit on a few cards that could be reproduced as often as needed. Thus, any library could have a copy of every book without the need for more space or concerns about deterioration due to age or accidental damage. Although people boasted that the Lord's Prayer had now been engraved on the head of a pin, Feynman claimed nanotechnology could replace this with the contents of the entire 30-volume Encyclopedia Britannica. He also claimed it would be possible to make very tiny but powerful motors and batteries using nanotechnology. Because of his reputation as a prankster, many likely considered much of this to be just another example of one of his practical jokes, while others referred to it as "nano nonsense".

Frustrated, Feynman delivered his famous lecture on nanotechnology entitled *There's Plenty of Room at the Bottom* at a 1959 American Physical Society meeting where he reiterated these and other claims. He challenged other researchers to think about manipulating materials molecule by molecule or even at an atomic level and concluded his talk by offering a \$1000 prize to the first person who could build a working electric motor 1/64 inch or less on a side. He offered another \$1000 prize to the first person who could produce written text at 1/25,000 scale, which was the size required to print the entire *Encyclopedia Britannica* on the head of a pin. _ The motor prize was claimed the following year by a meticulous craftsman using conventional tools that did not involve nanotechnology since the designated size was not small enough. The second prize was eventually awarded 25 years later to a Stanford grad student who had successfully reduced the first page of Dickens' *A Tale of Two Cities* on a page measuring only 1/160 millimeter on a side, 20 times smaller than the human eye can see. This was accomplished by using electron beam lithography and Feynman was delighted since it confirmed his claim that nanotechnology would dramatically change our lives.

This is just now starting to take place. The U.S. market for nano-products was \$200 million in 2005 but is forecast to exceed \$4 billion next year and the National Science Foundation predicts it will be \$1 trillion by 2015. This extremely accelerated growth suggests that nanotechnology could transform our daily lives more than the Industrial Revolution or the discovery of electricity. Feynman did not live to see his prediction of nano motor and energy sources come to fruition but you soon may never have to replace batteries again or wait hours to fully recharge them. New batteries containing carbon nanotube ultracapacitors can completely recharge laptops and cell phones in a minute. Carbon nanotubes are rolled-up sheets of graphite about the width of a DNA molecule. Unlike conventional batteries that start losing their ability to hold a charge after a year, these will still be going strong long after such

devices have become obsolete. Carbon nanotube batteries can also provide an energy storage device ten times more powerful and much lighter than the latest batteries in hybrid cars. These will significantly reduce the need for gasoline and also outlive the life of the vehicle. Nano biobatteries that convert light into electricity are also being developed for a wide array of implantable devices, including an artificial retina.

A prominent nanotechnology researcher at Bell labs predicts that within the next year or two, ultrasensitive microphones double the diameter of a human hair will be installed in mobile phones. These will be able to tune in to sound from different directions but also have the ability to block out background noise not relevant to the conversation. A "liquid eye" lens would be installed in phones in as little as three or four years that will enable to detect whether the person on the other end of the line was paying full attention to the conversation. It will respond much in the same way as a human eye, moving if something caught its attention, he said. Within a decade, cell phones will also have an "electronic nose" to detect the specific pheromones that make up an individual's scent and could be used as a "hacker-proof" security system to replace four-digit pin numbers and secret passwords.

Breakthroughs in nano fiber research have already resulted in fabrics that repel any stubborn stain, neutralize static charges that attract fuzz, are more durable and wrinkle free, evaporate excess moisture away from the skin to provide cooling and can also change color depending on the temperature. Nano plastic engineering advances will allow future walls to automatically adjust room temperature, open and close windows, emit light, speak words and change colors because of built-in solar cells that collect, store and transmit energy to different molecules embedded in the same type of material used for soda bottles. The "walls have ears" is a common expression but new 7 millimeter thin soundboards of special polyurethane are already replacing speakers because of superior surround sound. These soundboards vibrate because of generators that are fine-tuned to the treble, mid-range and bass frequencies of the surface material of the wall or floor behind which they are concealed. The acoustic guitar's sound comes from similar vibrations of its thin outer wall and patented high precision digital "pursonic" sound technology has improved on this principle to create a stunning and truly surround sound quality. Interior car paneling using similar nano soundboards could soon replace car stereo speakers because of superior quality.

Self-cleaning bathrooms are now available with a new material made up of titanium dioxide nanoparticles that continuously clean the surfaces of tiles and glass using light to do the scrubbing. The titanium dioxide nano particles absorb UVA light and use its energy to oxidize dirt and bacteria and convert them into harmless carbon dioxide and water. While this originally only worked outside with sunlight new coatings also respond to artificial light. An ordinary 60 -100-watt bulb will kill coliform bacteria and reduce the need to use disinfectants and other chemicals. Other coatings containing nanoscale aluminum or silver particles embedded in a very thin plastic layer also provide germicidal benefits due to the "lotus effect", which refers to the lotus plant's ability to repel water. Because of the coating's nano-properties, bacteria, oil, dirt, lime and even water can't stick to its surface. Every drop of water that runs over it takes the deposits with it, dripping off and rendering the surfaces clean again. Scalpels, hemostats, needles, retractors and other surgical instruments are now being constructed with similar coatings that will help keep them sterile and safer for longer time periods. Researchers have also been able to process an inexpensive polymer to repel water- based fluids better than even a freshly waxed car. Even drops of honey roll right off and this super water repellant plastic will make it possible to have free flowing honey and ketchup containers that deliver the very last drop as well as self washing building walls where any dirt is washed away when it rains.

Feynman's belief that we could also learn a lot by uncovering the nano secrets of Nature was also on target. Bird beaks are typically short and thick or long and thin. But the brightly colored beaks of toucans are both thick and long and equally effective for gathering tiny fruit from the tips of branches or functioning as a powerful nutcracker. Scientists have found that the beak's interior is a highly organized matrix of stiff bone fibers embedded in a "foam" of air-tight cells that gives it more rigidity with very little additional weight. They are now duplicating this to develop ultra-light aircraft and vehicle components using synthetic foams made with metals and polymers. Gecko lizards can walk up walls and even hang from the ceiling by one toe because of their remarkable footpads. Each five-toed foot is covered with microscopic elastic hairs that are split at the ends to form a forest of nanoscale fibers. These make such extremely close contact that they form intermolecular bonds that bind the foot to most surfaces. Researchers have now created a densely packed carpet of carbon nanotubes that function the same way but with 200 times more gripping power to make dry adhesives for microelectronic, robotic and space technology applications. They have also learned how sponges are able to use proteins to make their silica needles and are trying to copy this to make more powerful silicon chips for computers, telecommunication and fiber optic devices.

Nano Breakthroughs In Diagnosing, Treating And Preventing Disease

Abalone and oysters have also given up their secrets of strength that may lead to denser and more fracture resistant artificial bone. The sturdiness of these and other mollusk shells is due to nacre, a finely layered iridescent shiny substance produced on the inner surface of shells in response to irritation, which is how pearls are also made. When seawater freezes, crystals of pure ice form layers, while impurities such as salt and microorganisms are expelled from the forming ice and become trapped in channels between the ice crystals. The result is a multilayered structure that roughly resembles nacre's wafer-like construction. To mimic this, scientists created a watery suspension of hydroxyapatite, which is the mineral component of bone. When frozen, this similarly concentrates in the space between the ice crystals, creating layers and layers of nacre-like material that are also tough but light. They then learned that by increasing the rate of the freezing process, the layered structure became smaller and they ultimately obtained a microstructure measuring one micron, or one-millionth of a meter. After the ice was removed they were left with a porous scaffolding of hydroxyapatite layers that locked in place just like nacre and very much stronger than the porous hydroxyapatite materials currently used as bone substitutes. In addition, the space between the scaffolding's layers can be filled with an organic polymer that degrades over several weeks, liberating antibiotics and compounds that stimulate bone growth. This dense hydroxyapatite-polymer composite could be inserted wherever new bone is needed since as the polymer degrades, the scaffolding becomes more porous, prompting bone cells to invade the newly created pores. Artificial joints made of this composite could soon replace those made from metal alloys and ceramics that often trigger inflammation and immune responses or require corrective surgery after only a few years.

Nanotechnology tissue cell culture engineering advances are creating substitute skin that looks and functions like normal skin with the same soft, smooth texture, strength, durability and color pigmentation. Even under the best circumstances, the healing of skin wounds is an imperfect process since when the lower portion or dermis is damaged, a dense form of collagen is quickly created to cover the wound. However, it is so thick that no hair roots, sweat glands and few nerves or blood vessels can grow in it. As a result, functionality is lost and as the collagen heals, it shrinks, pulling on the surrounding skin. Traditional grafts can reduce these problems but often do not take or become infected and slough off. This new synthetic substitute skin knits with the surrounding tissue to spur the growth of sweat glands, hair follicles and blood vessels to supply oxygen and nutrients and promote healing without scar formation. One version has already proved successful in several dozen catastrophic burn patients not expected to survive, including one with third degree burns over 80% of her body. Burns over 30% of the body of any degree are usually fatal.

Some of the most exciting bionanotechnology advances are in applications to improve the diagnosis and treatment of disease, including:

- Earlier detection of an impending heart attack now referred to as the "Clinton Syndrome" due to the former president's sudden and unanticipated heart attack that required emergency quadruple bypass surgery. This vivid demonstration that even someone who had regular checkups and access to the best medical care resulted in physicians being flooded with worried middle-aged men concerned that their hearts might contain a similar unsuspected ticking time bomb. Such heart attacks are often due to inflamed plaque that is unstable and prone to rupture, causing blockage of a coronary vessel. This life-threatening situation may be undetectable by conventional imaging techniques if the plaque is not big enough to significantly impair blood flow. Identifying such asymptomatic patients at increased risk has now been made possible by using nano-sized contrast agents along with ultrasound inside blood vessels. This new technique generates cross-sectional images that highlight those areas of inflamed plaque most likely to rupture within the next twelve months.
- Alzheimer's disease is associated with the deposition of beta amyloid plaque in the brain that many believe are responsible for its devastating symptoms. When gold nanoparticles were attached to beta amyloid fibrils and subsequently exposed to weak microwave fields in test tube studies, the amyloid plaque dissolved and did not reappear. Animal studies are planned and damage to healthy brain tissue is unlikely since the energy levels of these fields is six times smaller than those from cell phones. This approach may have potential for treating Parkinson's, Huntington's and other neurodegenerative diseases that are also characterized by the aggregation of various proteins.
- Early diagnosis of genetic disorders. Devices made of carbon nanotubes can detect mutations in genes that cause hereditary diseases much more rapidly and at a lower cost than current techniques. Researchers have already utilized the electrical properties of these carbon nanotubes to find a particular mutation in the gene that causes hereditary hemochromatosis, a disease in which too much iron accumulates in body tissues.
- Femtosecond (**one quadrillionth of a second**) laser pulses are being used for diagnosis and treatment at a cellular level. Depending on the laser power and optics used, a "femtoscope" can visualize living tissue a thousand times more precisely than the best computer tomographs. Femtosecond laser surgery can function like tiny "nano-scissors" to insert genetic material into cells or cut nerve axons that send impulses to muscle cells.

Improvements in the diagnosis and treatment of cancer may come from a great variety of innovative techniques. Consider just the following half-dozen:

1. Nanoshells are particles about 20 times as small as a red blood cell and made of a silica core covered by a thin gold shell. These gold nanoparticles are attracted and bind to epidermal growth factor receptors that stud the surface of cancer cells but are rarely found on normal cell membranes. By "varying the size of the core and the thickness of the gold shell, researchers can tweak a nanoshell to respond to a specific wave length of light delivered by a laser beam directed to the tumor. When these nanoshells are tuned to this wavelength, they convert the light into heat that destroys cancer cells without injuring adjacent healthy tissue. In one study where squamous cell cancers had been implanted in animals and this technique was used, surface temperatures above the tumors jumped an average of 46 degrees Fahrenheit and all the tumors disappeared within 10 days. Trials in humans are expected to start shortly.
2. A nano "Trojan horse" may be used to smuggle a powerful chemotherapeutic drug inside tumor cells to increase its effectiveness and reduce toxic side effects. The drug delivery vehicle used is a man-made star-shaped polymer three or four nanometers in diameter called a dendrimer. This is about the size of a hemoglobin molecule making it small enough to slip into cells through tiny openings in cell membranes. Dendrimers have a tree-like structure with many branches where scientists can attach different molecules. In

one report, scientists attached methotrexate, a powerful anticancer drug, to some branches of the dendrimer and on other branches they attached fluorescent imaging agents and folic acid, an important vitamin crucial for the healthy functioning of all cells. However, cancer cells need increased amounts of folate to fuel their rapid growth so they have many more folate receptors on their cell walls to soak it up. As the lead author explained, "It's like a Trojan horse. Folate molecules on the nanoparticle bind to receptors on tumor cell membranes and the cell immediately internalizes it, because it thinks it's getting the vitamin it needs. But while it's bringing folate across the cell membrane, the cell also draws in the methotrexate that will poison it." When tested in laboratory mice that had received injections of human epithelial cancer cells, this nanoparticle-based therapy using folic acid and methotrexate was 10 times more effective at delaying tumor growth than methotrexate given alone and far less toxic.

3. Plastic beads 20 to 600 nanometers in size called PEBBLES (probes encapsulated by biologically localized embedding) can be coated with targeting molecules to provide a very precise contrast agent for imaging, drug delivery or to destroy cancer cells. A high velocity device is used to blast them like little bullets to attach to liposomes that cells readily import. Once they reach their goal, sound or light can be used to trigger them to function.
4. A cancer "nanobomb" has been developed using carbon nanotubes that can literally blow up breast cancer tumors. The bombs are created by bundling the carbon nanotubes and then exposing them to the near infrared light of a laser. If a single carbon nanotube is exposed to the laser the resultant heat is quickly dissipated, but when they are bundled, so much heat is generated that they start exploding in succession like a cluster bomb. This could be particularly effective in breast cancer because the heat shockwave kills not only the cancerous cells but also biological pathways that carry instructions to generate additional cancerous cells and the small veins that nourish the diseased cells. This method is now also being explored to treat prostate and pancreatic cancers.
5. Another technology being tested involves a hydrogen-carbon polymer nanoparticle with bits of Taxotere, a FDA approved drug for treating prostate cancer bound up in its fabric. This is attached to a substance that homes in on cancer cells where the polymer very gradually dissolves to slowly release nuggets of the drug. In one study in which human tumors created from prostate cancer cell lines were implanted in mice, cancers disappeared within a month or two in all who received nanoparticles containing Taxotere but not in those injected with regular Taxotere.
6. Preventing the side effects of chemotherapy and radiation may be achieved using carbon-based nanoparticles called fullerenes. These soccer ball-shaped hollow structures attract and bind unstable free radicals resulting from tissue injury due to radiation and chemotherapy that prevent them from racing around the body and damaging healthy cells.

There are also numerous preventive medicine and Public Health nano applications. Some 13 million people die from waterborne infection every year and others from drinking water contaminated by toxic chemicals, like the 23 Massachusetts children who died from trichloroethylene (TCE) poisoning. Nanotechnology is making water safer because of nanoscale membranes that filter out contaminants, nanoscale polymer "brushes" coated with molecules that capture and remove poisonous metals, proteins and microbes, as well as photocatalytic nanomaterials that allow ultraviolet light to destroy pesticides, industrial solvents and germs. Researchers have also found that nanoparticles of gold coated with palladium can quickly remove TCE from groundwater thousands of times faster than current methods. Detecting water or air pollution will also be markedly improved by more powerful sensors that are activated by minute traces of any pathogen, dangerous gas or increase in radioactivity.

The antibacterial properties of silver have been known since antiquity. Nanotechnology has now been able to take full advantage of this by maximizing the availability of silver ions, the most

potent form of this element. These are now being used to prevent and treat deadly antibiotic resistant infections. One company has invented a process to deposit silver particles less than a thousandth the diameter of a human hair on medical devices like urinary catheters that are common sources of infection. These nanoscale particles have so much surface area that minute concentrations are effective. According to one authority, "The equivalent of a teaspoon of silver nanoparticles in a seven-lane Olympic-size swimming pool is enough to do the job". Silver nanocrystals between 1 and 100 nanometers that provide sustained release are also being used in dressings to prevent infection and reduce the need for frequent changing. A new transparent wound dressing using a nanostructured membrane allows air and moisture to pass through, while protecting the injury from bacterial infection. Drug delivery systems can be embedded in the membrane to allow sustained medication release and cells can be grafted onto the dressing to promote tissue regeneration and accelerate healing. As a bonus, the membrane sticks to skin at body temperature, but releases without damaging newly formed skin when chilled with an icy cloth.

Greater protection from skin cancers will come from products containing invisible zinc oxide nanoparticles that absorb UV light but allow visible light to pass through that are already available in some Australian sunscreens. These also contain other sun-blocking ingredients that can break down over time and cause the release of free radicals that damage skin and DNA. "UV-Pearls" can prevent this by encapsulating all the active ingredients in highly transparent silica glass nanospheres that allow them to function without having any direct contact with the skin. Described as "Sunglasses for the Skin", these UV-Pearls are completely safe and inert and are already starting to appear in some sunscreens and daily wear cosmetics. A nano-coated nylon has been developed that protects against UV radiation in thick fibers for outdoor clothing as well as thin materials for summer fabric. The material has a SPF over 60, dries quickly, is light, resistant to abrasion and extremely tear-proof.

What Are The Drawbacks, Deficiencies Or Dangers Of Nanomania?

All of the above seems wonderful and exciting and this is just the tip of the iceberg. There will be numerous other advances that are likely to improve medical care and public health over the next decade as more and more people jump on the nanotechnology bandwagon. However, many are concerned that this nanomania may have a downside that is not yet appreciated because we don't know enough about the long-term consequences of switching to certain nanomaterials. Many promising new technologies like DDT were hailed as triumphs until it was learned years later that in addition to killing insects, it was also lethal to eagles, falcons and other birds of prey. Chlorofluorocarbons introduced in the 1920's were the coolants of choice for refrigerators and air conditioners for over 7 decades years until it was found that they destroyed the Earth's ozone layer and were eventually banned.

Some scientists are concerned that zinc oxide nanoparticles in sunscreens could be absorbed into skin cells and possibly interact with sunlight to damage them. Others worry that the ability of some nano particles to pass through cells could allow them to pass into the blood stream and lodge in brain, lung, kidney or other tissue or other organs. In one recent animal study, carbon nanotubes used to deliver drugs were found to promote blood clotting. Buckyballs are a microscopic form of carbon discovered in 1985 and named after Buckminster Fuller, who invented the geodesic dome. While buckyballs can enable much faster Internet speeds and communications through cellular networks and phone lines, preliminary studies suggest that they can also kill waterborne bacteria and break down brain cells in fish. We don't know what will happen when buckyballs wash out of consumer products and into sewage plants that discharge into lakes, rivers, or coastal waters. What will happen when factories that produce or use buckyballs discharge their wastes directly into waterways? There are no clear answers and laws such as the Toxic Substances Control Act, the Food, Drug and Cosmetic Act, and the Federal Hazardous Substances Act must all be rewritten to include safety provisions for nanomaterials. Labor unions and environmentalists are concerned about possible safety and health hazards and some trial lawyers have compared nanotechnology to asbestos, which has been plagued by more than \$70 billion in litigation over the past three decades

Since nano-devices are too small to be seen by the human eye, some fear that they could be used to control human brains or record and transmit private conversations. Others are concerned that nano devices will lead to gadgets that will make us progressively lazier or intensify deadly coronary prone Type A behavior. A February 3 *Wall Street Journal* article described a \$150,000 system recently installed for a 35-year-old Wall Street investor designed to make him productive the moment he opens his eyes. "When he shuts off his alarm, automatic shades gradually let sunlight in the bathroom. Then the towel warmers switch on, the floor warms and the toilet seat heats up. When he turns on his faucet, a 15-inch LCD screen appears in the mirror with a touch panel full of icons; he can click on a 'Bloomberg' logo to see his portfolio, an 'email' logo to check messages and a 'TV' logo for morning financial news." And behind that screen is a computer. Another Type A CEO with a Blackberry, two mobile phones, three office computers and wireless Internet for his car now also wants to make sure that being in the bathroom will not keep him out of the loop. "When he answers the speaker-phone in his shower, the water automatically shuts off. He can open the front door for deliveries while shaving. He's also put the finishing touches on a waterproof computer that will let him answer emails from his sauna." The article goes on to describe how similar "Type A" bathrooms are quickly becoming the new home office for workaholics.

One cannot help but be reminded of Oswald Spengler's *The Decline of the West*, one of the most widely discussed books in the 1920's and 1930's. It was a brilliant review of all great cultures showing that there were certain common characteristics that were associated with their growth, maturation and decline. One of the most consistent features that predicted the end of a civilization was a preoccupation with products and gadgets that promoted personal comfort. A good example was Rome in the third century A.D., when it was at the height of its power. Engineers had constructed roads all over the vast empire equal to ten times the circumference of the earth at the equator. They didn't hesitate to cut through hills, tunnel under mountains, build sturdy bridges over rivers and valleys, and their "freeways" were as straight and flat as possible. Many of these are still in use. They built extensive water supply and sewer systems some of which were large enough to drive a wagon through and still function. Water was everywhere, supplied by fantastic aqueducts over long distances. Hot-and-cold-water public baths were a must to the Romans. There were over 800 public baths in the city of Rome itself and wealthy people had furnaces under their houses with warm air circulating through pipes or ducts in the walls. No one could have imagined within a hundred years, the great Roman Empire would be conquered by barbarians and disappear. Spengler accurately predicted World War II, the fall of Germany and warned that Western civilization was on its way out because of its growing preoccupation with creature comforts and gadgets. Will nanotechnology provide the crowning blow? It is the death knell for our civilization or will it possibly ring in the birth of a new and better one?

Only time will tell. For the present, perhaps it is best to take advantage of and enjoy the benefits nanotechnology can provide while remaining sensitive to the dangers it might pose for future generations.

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