

NANOPARTICLES BEFORE NANOTECHNOLOGY

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Nanoparticles Before Nanotechnology

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CREDITS:

contributors: josep saldaña cavallé, víctor puntes
 designer: joan escofet planas
 3D design team: ux hax, romy nayar , maria grot and
 lanjran choche
 photography: ux hax

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 Catalan Institute of Nanotechnology
www.icn.cat



Nanoaracat
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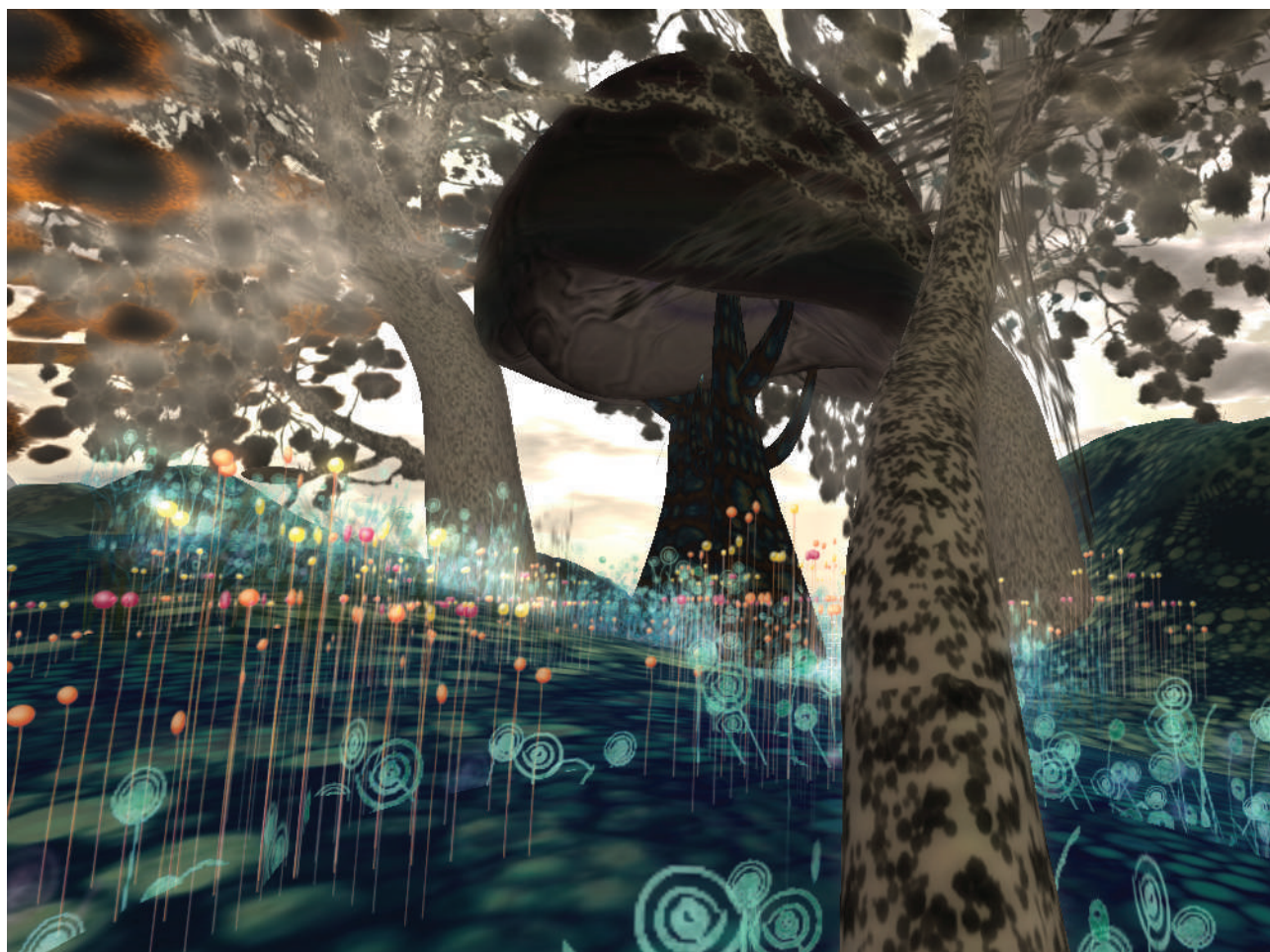
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NANOPARTICLES BEFORE NANOTECHNOLOGY



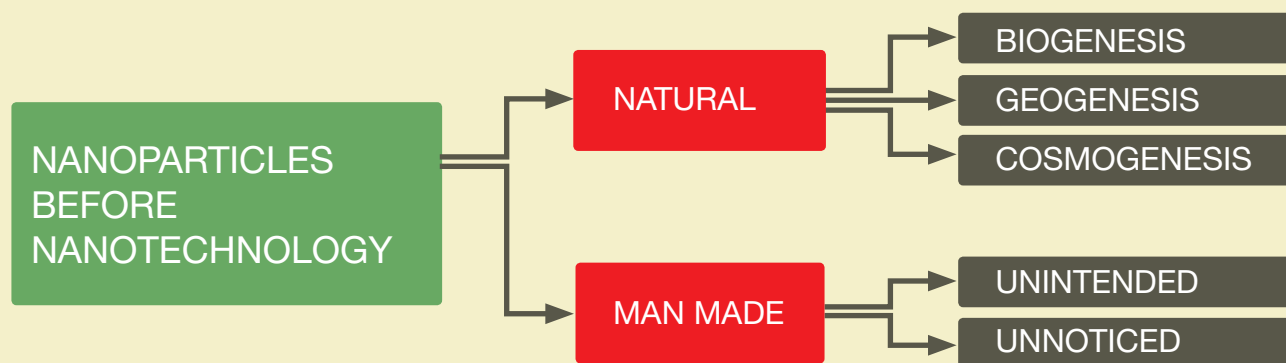
Introduction



We are glad to present another NanoWiki compilation, following *Balancing the promises* [1] and *Engines On* [2], and this time focusing on **Nanoparticles Before Nanotechnology**. For this piece we would like to perform the simple task of selecting, condensing, and classifying the news that appeared on the subject in the Nanowiki, especially highlighting the ones that appeared in 2011; a collage of press releases on the selected topic and additional comments. This aims to provide you with an easy overview of relevant aspects of the state of knowledge on the occurrence of natural, unintended, and unnoticed nanoparticles (NPs), with access to all the relevant information.

This year we chose the subject of nanoparticles before nanotechnology simply because we were suspicious that nanoparticles are too often, in

scientific and non-scientific circles, perceived as *invented*, while we think they should be understood as *discovered*. Nanomaterials are claimed to be so new that people become scared. However, before nanotechnology, one can find nanoparticles in the works of both nature and Man, although they passed unnoticed by us until recently. The origin of nanoparticles in nature is basically i) **biogenic**, ii) **geogenic** (and also at the bio-inorganic interface), or iii) **cosmogenic**, while the nanoparticles produced by men come **unintentionally** from origins as burning wood and oil or **unnoticed** in crafted stuff such as cosmetics and colored glass and ceramics.



Additionally, **to bring nano closer to society**, following the same demystifying aims, we present a set of experiments, **Hands On** [see page 33] [3], in which some basics and useful nanoscale phenomena can be easily observed, such as preparing photonic crystals that look like opals, disinfecting water, or harvesting energy.

The very physicochemical nature in which we are immersed somehow favors the existence of nanostructures. Among these physical laws is the inorganic version of molecular principles [4]; the precise combination of atoms into single entities with such precision that they become excellent building blocks that form, for example, the structure that shapes us (skeleton). This formation is determined by the behavior of atom aggregates at a certain temperature and in a certain environment. Nanoparticles are found in the cosmos, in the air, water, soil and inside living bodies. NPs are central to many geochemical and atmospheric processes and they respond strongly to the environment throughout their complete life span. Nanoscale minerals may be formed in the environment as a result of microbial activity or inorganic precipitation and weathering. In fact, the ubiquity of mineral NPs in oceans and rivers, atmosphere and soils, and in living cells influences our own planet's physical, chemical, and biological processes,[5] for example, the naturally occurring iron oxide NPs in lava act as an effective natural catalyst for the production of carbon nanotubes. Similarly, nanowires found on the outside of *Geobacters* effectively mineralize radioactive material, preventing them from leaching to ground water. Nanoscale reactions resulting in the formation of phytoplankton nanostructured biominerals, such as calcium carbonate, are important influences on oceanic and global carbon cycling. In fact, biological organisms use NPs to survive hostile environments, sequester toxic ions (mineralization of toxins), and

to store micronutrients. Conversely, harmful heavy metals can be widely dispersed courtesy of nanominerals; for instance, nanominerals are involved in the transport of lead, arsenic, copper, and zinc over hundreds of miles. All these examples show how natural NPs can teach us in the design and production of more effective and environmentally compatible NPs. Needless to say, despite specific differences between engineered and natural NPs, we expect some similarities in their environmental behavior and interaction with biological systems.

Therefore, although humans have always been exposed to NPs of natural origin, from marine aerosols to volcanoes or forest fires, as well as to man-made NPs, starting with ancient cosmetics or pigments (such as the TiO_2 NPs found in the alveoli of a mummy over 5000 years old), such exposure, mainly to carbon-based nanostructures, has significantly increased in the past century due to anthropogenic sources, such as internal combustion engines, power plants, and many other sources of thermodegradation of organic matter, which produce, among others, fullerenes (C_{60}) and carbon nanotubes (CNTs). This rises concern about the impact of NPs in human and environment health.

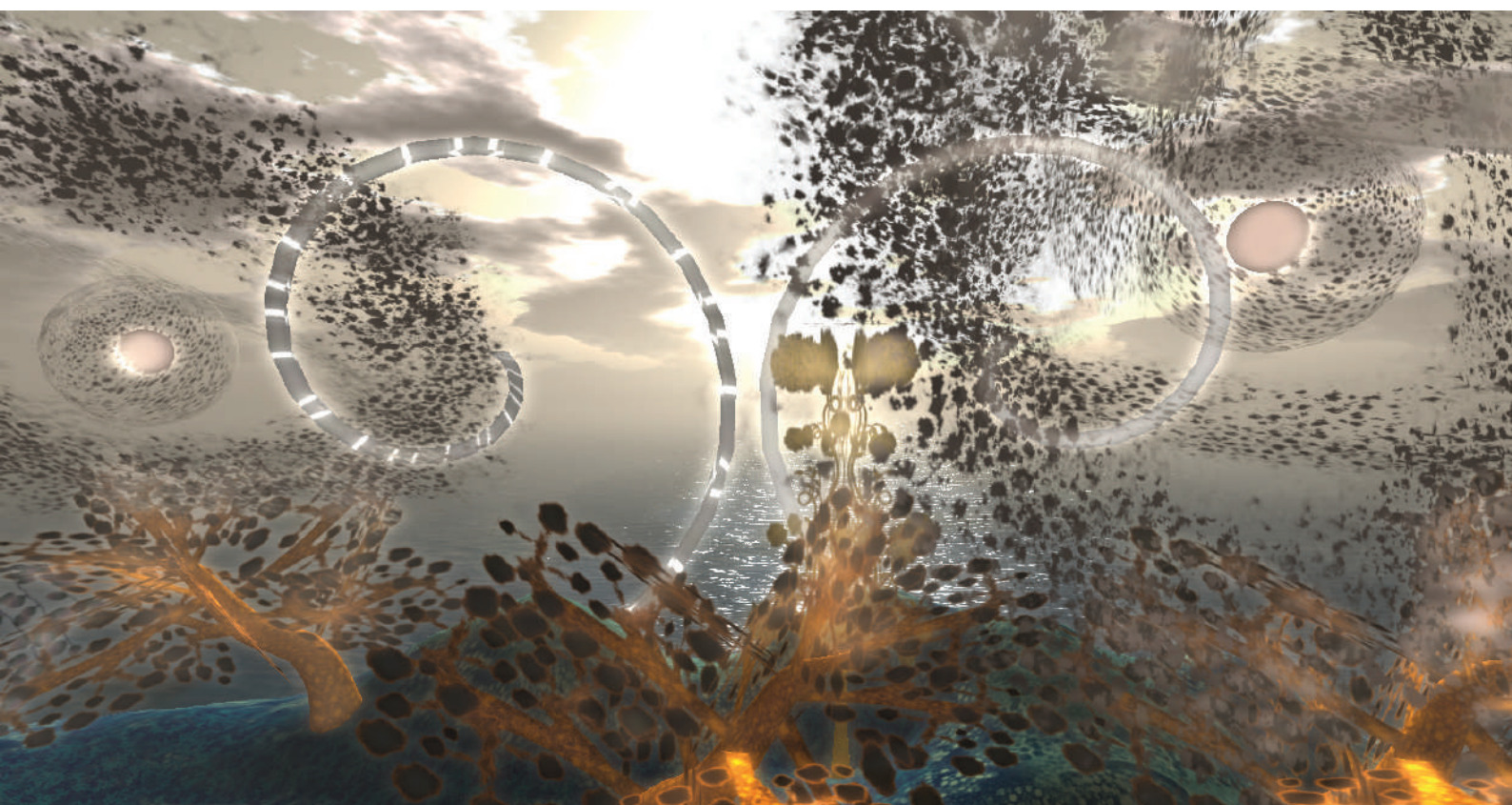


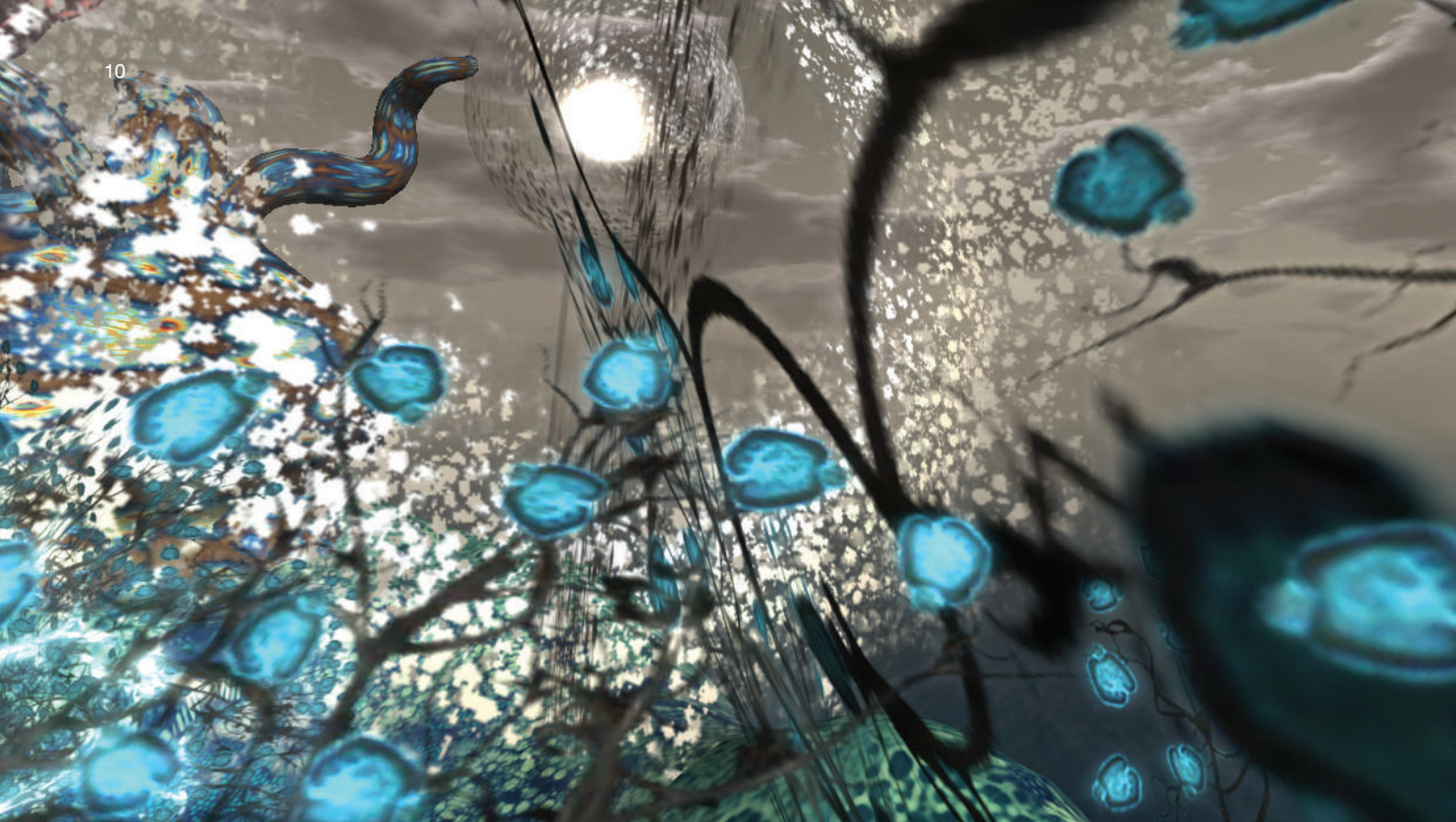
The biogenic nanoparticles: Proteins and Magnetite

Nanominerals are widely distributed throughout the atmosphere, oceans, rivers, lakes and underground waters, soils and, in most living organisms, even within proteins. Biogenic NPs occur naturally in many species, ranging from bacteria to protozoa to animals, for example, magnetosomes from magnetotactic bacteria, or ferritin, an iron-storage protein some 12 nm in diameter that contains a core of 5–7 nm hydrous ferric oxide NPs, found in most animals and also found in humans. In biology, the role of nanominerals is far-reaching.

Nano on the leaves. When a water droplet is deposited on the surface of a solid body, the shape that the drop takes will depend on the force of gravity, the forces of interaction between water molecules, and the forces of interaction between the water molecules with atoms or molecules of the solid with which it is in contact. The latter two forces will determine the degree of adhesion of a liquid to the solid, a property that is qualified in terms of the *wettability* of the liquid relative to a solid. When the liquid wets completely, it forms a thin layer on the surface of the solid, whereas if the liquid does not “like” the surface, it tries to minimi-

ze the contact area and a spherical droplet is formed, subject to the effects of gravity. When there is low friction between the liquid and the surface and very low adhesion, the surface is known as *superhydrophobic*, where the chemical composition and structure of the surface topography are recognized as major causes for this existence of low adhesion and friction on the surface. In the lotus leaf, the superhydrophobicity can be explained in terms of the presence of microscopic papillae with small nanometric wax crystals, which reduce the surface energy and therefore produce low adhesion. Furthermore, a microscopic papillary structure traps air in the interstices and provides conducive conditions in which the water can move. Recent research has shown that microscalar structures sizes on the order of 10 μm are used to support nanoscale-type structures with sizes on the order of 40 nm. This hierarchy of scale in structure recalls to us the bone (*vide infra*). Such self-cleaning superhydrophobic leaves have been a model that is much imitated for the manufacture of self-cleaning nanostructured materials. Contaminants that usually come in contact with the superhydrophobic surface are larger than the microscopic structures





located on the surface, which results in a low contact area with a minimum interfacial interaction between the pollutant and the corresponding surface. Since there is little water adhesion, droplets roll easily, and pass on the particle of dirt that is then captured and ends up leaving the surface. Unlike the lotus effect, in which there is favored adhesion of water to the surface, a behavior known as *petal* effect has been identified, since it is found in some rose petals. This case involves a micro–nano binary structured surface with high adhesion of water, but which does not wet. This effect has motivated the study of surfaces of rose petals, which have a periodic array architecture of “mounds” of a size about 60 nm. Some research groups have mimicked the structure of the petal with interesting results for industrial applications. Not all rose petals surfaces display this effect.

Another particular case is eucalyptus leaves [**Eucalypt's nano properties**] [6]. Scientists have discovered that a eucalyptus plant native to south-west Western Australia has also unique self-cleaning and water-repellent properties. The Mottlecay, which is also known as The Rose of the West for its large spectacular flowers, has silvery leaves which are covered in a wax that produces nanosized bumps and pillars. This structure causes water to form droplets that roll over the surface of the leaves and fall towards the root system of the plant, picking up any dirt along the way and collecting all possible trapped water from the

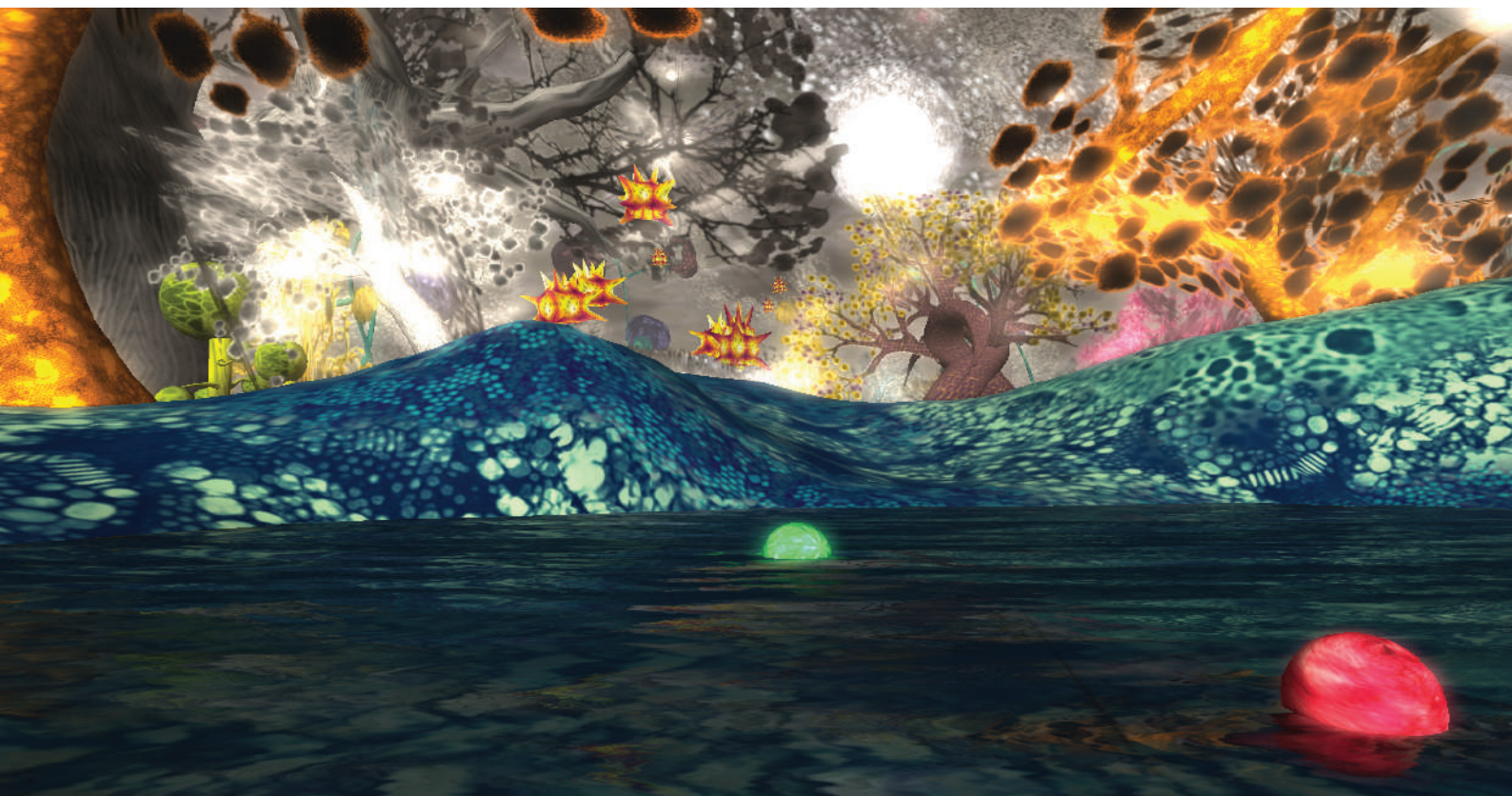
leaves. These properties similar to those of the lotus plant, have inspired a range of self-cleaning and antibacterial technologies currently being developed. Applications of the lotus effect include development of ecological paints and coatings with self-cleaning ability, improving those currently offered on the market, which also allow an extreme resistance to water moisture and protection against contamination: if it rains, the paint is completely clean. Lotus-effect coatings for plastic, ceramic, boats, car glass, textiles, leather, wood, and anti-graffiti protection are among the potential uses of these micro- and nanostructured materials. In textiles, there are already fabrics manufactured with nanoparticles (such as hydrophobic teflon) that do not get wet or dirty, or umbrellas that remain dry, which reduces by 70% the need for cleaning products; this is good for the care and preservation of the environment.

A significant challenge in the development of new technologies of nanostructured surfaces is the ability to change their wetting properties depending on some external signal, such as light, heat, or electrical potential. Certain types of compounds (e.g., azobenzene and its derivatives) undergo changes in wettability when bathed in visible or ultraviolet light, something that can be exploited to design coatings able to program self-cleaning ability and adhesion in response to an external stimulus.

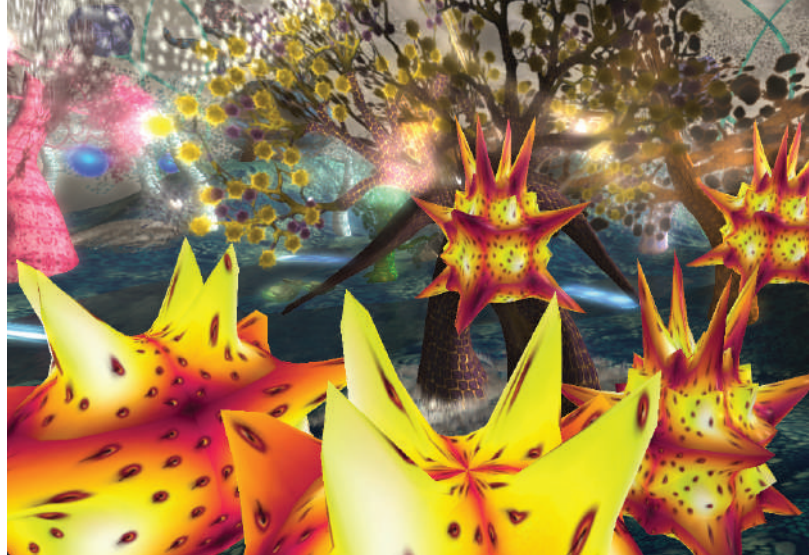
Nanoarchitectures in nature may be more common than we might suspect. Known for their wide variety of vibrant plumage, birds have evolved various chemical and physical mechanisms to produce these beautiful colors over millions of years. Some of the brightest colors in nature are created by tiny nanostructures with a structure similar to beer foam or a sponge. A team of paleontologists and ornithologists has now discovered evidence of vivid iridescent colors in fossil dinosaur feathers more than 40 million years old. The finding signifies the first evidence of a preserved color-producing nanostructure in a fossilized feather **[Reconstructing the colors of feathered dinosaurs]** [7]. Although fossil feathers have been known for many years, their original color had not been determined until now. When the roughness of the surface is in the range of the wavelength of the incident light, different colors are scattered in different directions producing iridescence [8]. And of course, not just the colors of ancient butterflies and dinosaurs, but also those of today's bird feathers can be finely produced by nanostructures **[Bird feathers colors produced by nanostructures]**



[9]. In fact, most colours in nature—from the color of our skin to the green of trees—are produced by pigments. But the bright blue found in many birds, such as Bluebirds and Blue Jays, is instead produced by nanostructures. Under an electron microscope, these structures look like sponges with air bubbles. This information provides new insight into how organisms use self-assembly to produce color, and has important implications for the role color plays in birds' plumage, as the color produced depends entirely on the precise size and shape of these self-assembled nanostructures.



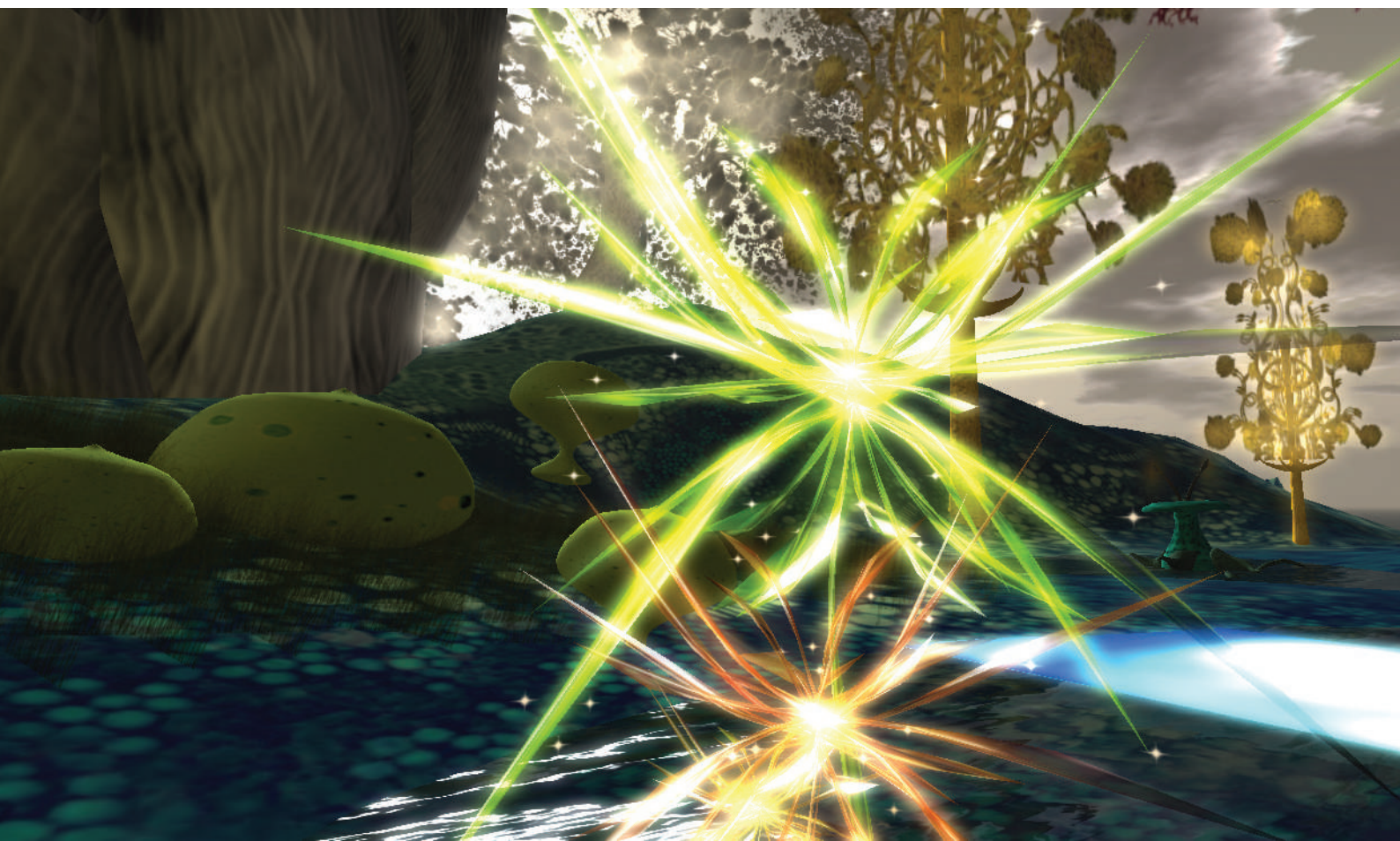
Bacterial nanosynthesis. Among the many examples of biomineralization, engineers have recently found semiconducting nanotubes produced by living bacteria—a discovery that could help in the creation of a new generation of nanoelectronic devices [**Nanotube-producing bacteria**] [10]. This is the first time that nanotubes have been shown to be produced by biological rather than chemical means, and it opens the door to the possibility of cheaper and more environmentally friendly manufacture of electronic materials. Thus, it was found that the bacterium *Shewanella* facilitates the formation of arsenic sulfide nanotubes with unique physical and chemical properties. The photoactive arsenic sulfide nanotubes produced by the bacteria behave as metals with electrical and photoconductive properties. Researchers reported that these properties may also provide novel functionality for the next generation of semiconductors in nano- and optoelectronic devices. In a process that is not yet fully understood, the *Shewanella* bacterium secretes polysaccharides that seem to produce a template for the arsenic sulfide nanotubes. Other interesting bacteria are magnetotactic bacteria; simple single-celled organisms that are found in almost all bodies of water. As their name suggests, these bacteria orient and navigate along



magnetic fields like miniature, swimming compass needles. This effect is thanks to the nanosized crystals of iron minerals produced by the bacteria [**Death Valley microbe may spark novel nanotech uses**] [11].

Magnetotactic bacteria found in the muddy bottoms of ponds and lakes use the Earth's magnetic field to distinguish up from down, which allows them to seek out optimal conditions for growth and survival (basically, optimal oxygen concentration). Their sensors are called magnetosomes; each comprises an ordered nanoscopic crystal of iron oxide (magnetite) or sulfide (greigite) enclosed in a specialized pocket formed by a fold in the cell membrane. Magnetosomes are arranged in linear chains, so that the nanomagnets they contain act as compass needles that enable the cells to follow geomagnetic field lines. As the magnetic core of the planet is smaller than the planet itself, there is always an enough out-of-plane component of the

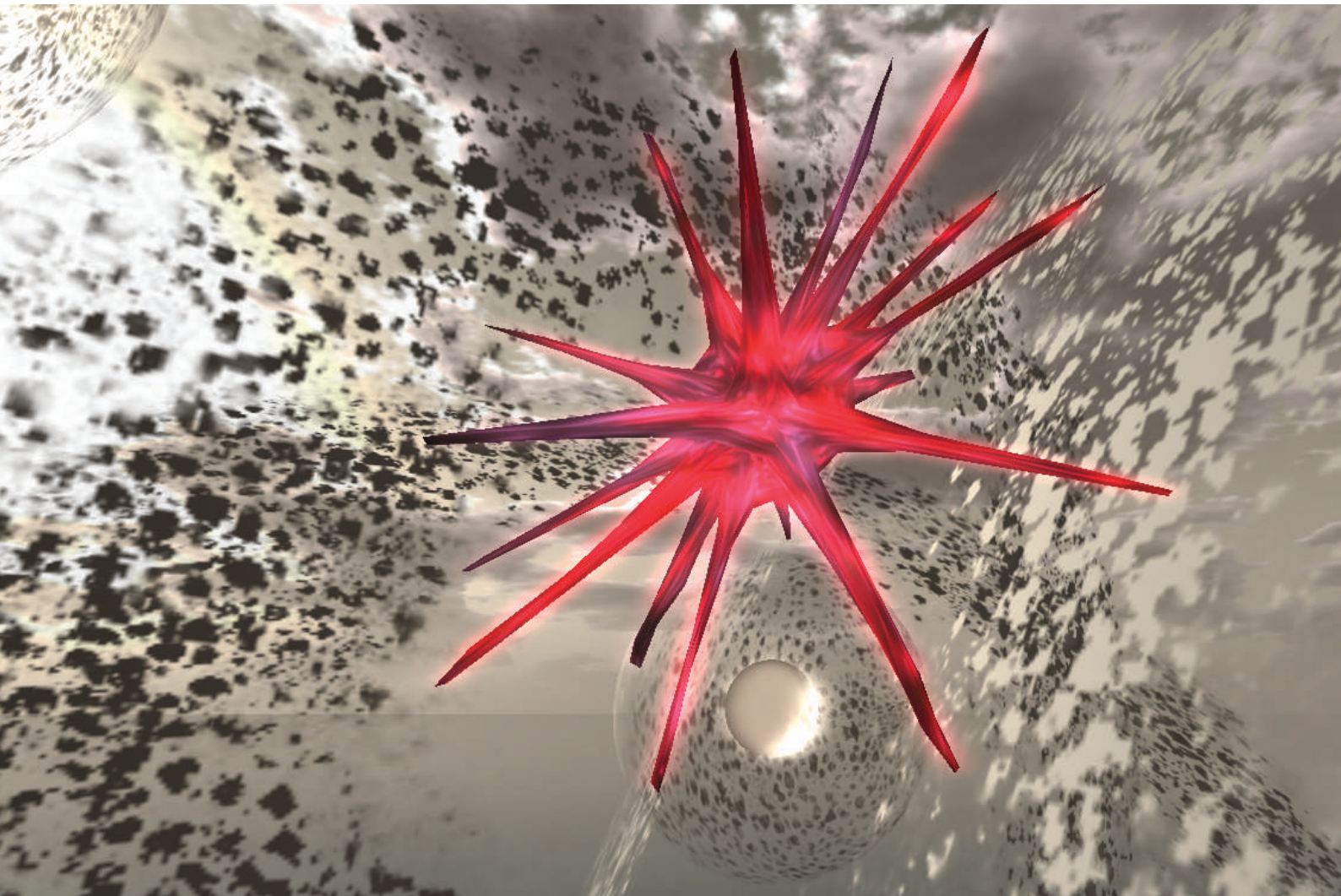




planet magnetic field indicating up or down, where different concentrations of oxygen are found. Only a few of these magnetotactic bacteria species grow readily in laboratory cultures. Results have shown, for the first time, that the genes required for the assembly of bacterial compasses derive from a single source, although they are now found in widely divergent groups [**How bacterial magnetosomes form**] [12]. The genes were most probably transmitted between otherwise unrelated groups by horizontal gene transfer. The presence of these magnetic crystals makes the bacteria and their internal crystals useful in drug delivery and medical imaging.

Other interesting bacteria also produce electricity [**Geobacter microbial nanowires to produce more electricity**] [13]. In recent experiments with *Geobacter*, the sediment-loving microbe whose hairlike filaments help it to produce electric current from mud and wastewater, the use of nanowires was observed. *Geobacter*'s hairlike pili are extremely fine, only 3 to 5 nm in diameter, and more than a thousand times longer than they are wide;

nevertheless, they are strong. Nicknamed nanowires for their role in moving electrons, pili are the secret to this particular microbe's ability to produce electric current from organic waste and sediment. *Geobacter* has been explored for decontaminating soil, due to its ability to respire iron and other metals in a way analogous to how we breathe oxygen. In fact, *Geobacter* showed promise for a variety of bioremediation tasks, but the microbiologists further discovered in 2002 that it could produce electricity from the organic matter found in soils, sediments, and wastewater. This ability was attributed to particular features of the electrically conductive pili, which were discovered in 2005. Together, these discoveries have led to intense research on how to harness the microbes for producing electricity in microbial fuel cells. Microbial fuel cells, which convert fuel into electricity without combustion, consist of an electrode known as an anode that accepts electrons from the microorganisms, and another electrode known as a cathode, which transfers electrons onto oxygen. Electrons flow between the anode and the cathode to provide a current that can be harvested to power electronic devices.



Natural *unintended* biogenic nanoparticles are causal to arterial disease processes [**Human-derived nanoparticles are causal to arterial disease processes**] [14]. Self-calcifying, self-forming nanoparticles have been isolated from calcified human tissues. In fact, this recalls how NPs are synthesized by microbiota to detoxify an excess of toxic ions. Here, in some manner, calcium ions reach their solubility limits and are mineralized to regain homeostatic equilibrium. However, it is unclear if these nanoparticles participate in the disease processes as cause, symptom, or consequence. Therefore, a study was designed to preliminarily test the hypothesis that human-derived nanoparticles are causal to arterial disease processes (which is only a short piece of the story).

This study offers the first evidence that there may be a causal relationship between in-body-derived NPs and response to injury, including calcification in arteries with damaged endothelium. The origin of the disease may be deregulation of Ca processing, and the presence of NPs the symptom. In fact, early atherosclerosis (calcification on the nanometer scale) has been imaged as reported in November

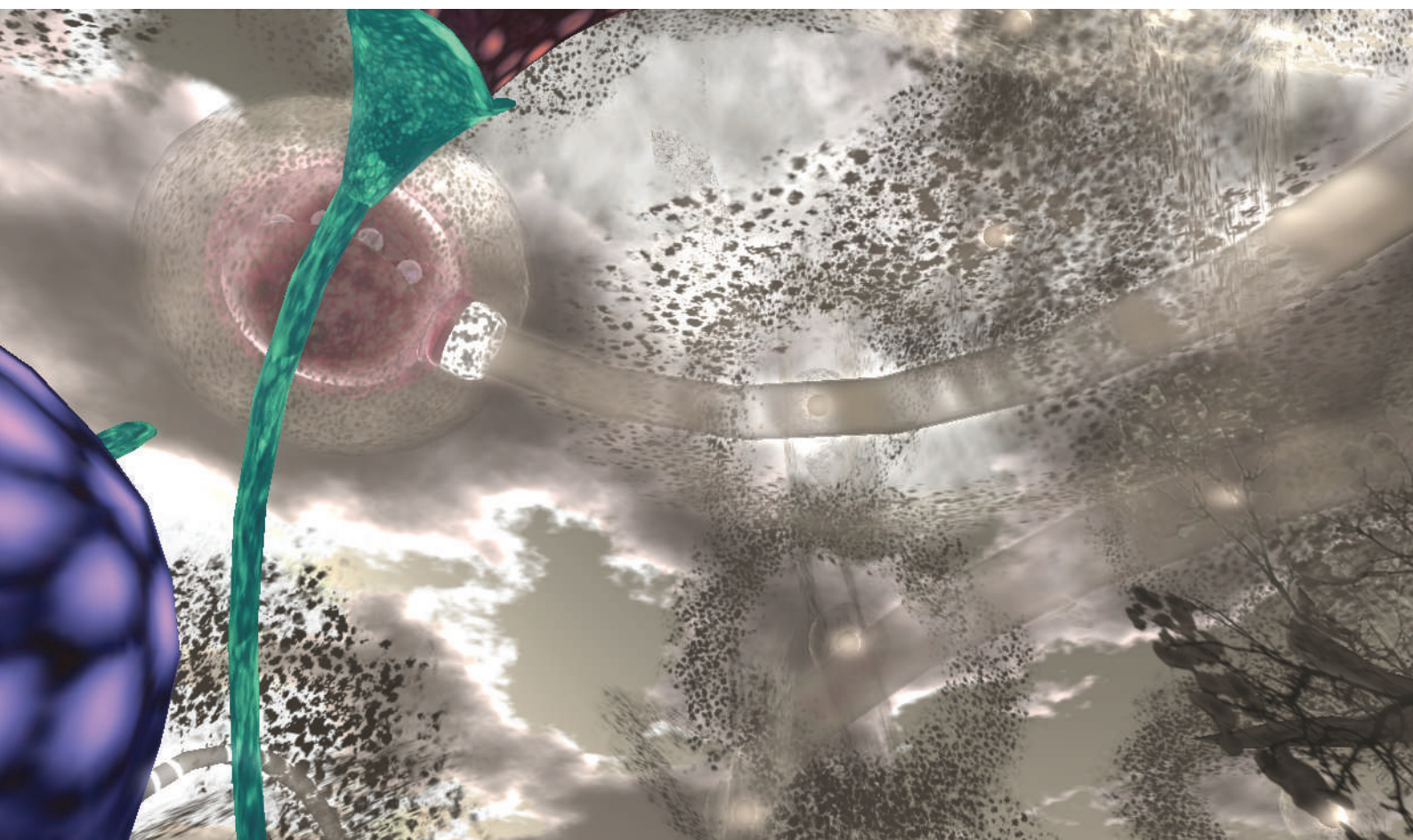
2010. [**Early atherosclerosis imaged: the calcification at a nanometer scale**] [15]. Atherosclerosis is characterized by hardening and thickening of artery walls, and has serious health consequences. Researchers have imaged the stages in the calcification on a nanometer scale. The growth of hardening follows almost the same process as bone or tooth formation, and follows chemical mineralization rules in biological environments. As long ago as 1965, Aaron S. Posner suggested how the calcification—the formation of calcium phosphate—in a biological environment takes place, although this met with considerable resistance at the time. However, these observations now confirm Posner's 45-year-old idea; calcium and phosphate ions dissolved in the blood are not deposited directly as crystalline material on the artery wall, but first pass through an intermediate phase. In this phase they form prenucleation clusters, followed by amorphous nanoparticles measuring approximately 50 nm. Only then does crystallization occur, causing hardening of the artery wall, following the rules of NP nucleation and growth. It seems that all (nano)mineralization systems in living beings take place in similar ways, and there are increasing

indications that it works similarly everywhere that nanomineralization occurs. Researchers hope that this understanding will be used to develop new forms of treatment for atherosclerosis.

Thinking about *in-house* biomineralization, bone is one of nature's surprising "building materials [**Bone's nanostructure**] [16]." Pound-for-pound it's stronger than steel, and is tough yet resilient. Scientists have identified the composition that gives bone its outstanding properties and the important role citrate molecules play within this structure; this work may help a better understanding and treatment or prevention of bone diseases such as osteoporosis. Using nuclear magnetic resonance spectroscopy, scientists studied bone, an organic-inorganic nanocomposite whose stiffness is provided by thin nanocrystals of carbonated apatite, a calcium phosphate, embedded in an organic matrix of mostly collagen, a fibrous protein. By understanding the nanostructure of naturally occurring materials, one may develop new light-weight, high-strength materials that will require less energy to be manufactured and that could make the products in which they are used more energy-efficient. The organic, collagen matrix makes bones tough, while

the inorganic apatite nanocrystals provide the stiffness. And the thinness of these nanocrystals appears to provide favorable mechanical properties, primarily in prevention of crack propagation.

Also recently, scientists have identified how nanosized motors in nerve cells help to regulate the balance of communication inside the brain. Such findings may also help to explain why communication between nerve cells is disrupted in neurodegenerative disorders such as Alzheimer or Parkinson's disease, leading to altered electrical behavior of nerve cells in this disease. Nerve cells send signals to each other by releasing chemicals at specialized junctions between the cells called synapses. One key neurotransmitter, called GABA, acts on special proteins (GABA receptors) to generate inhibition, which stops the brain from becoming too excitable. A protein named HAP1, working together with molecular motor proteins, helps to guide the GABA receptors to the synapses (a gap of about 40 nm). Researchers showed that the receptors are transported to synapses by small nanometer-sized motors on intracellular protein tracks called microtubules [**Nano-motors facilitate communication between brain cells**] [17].

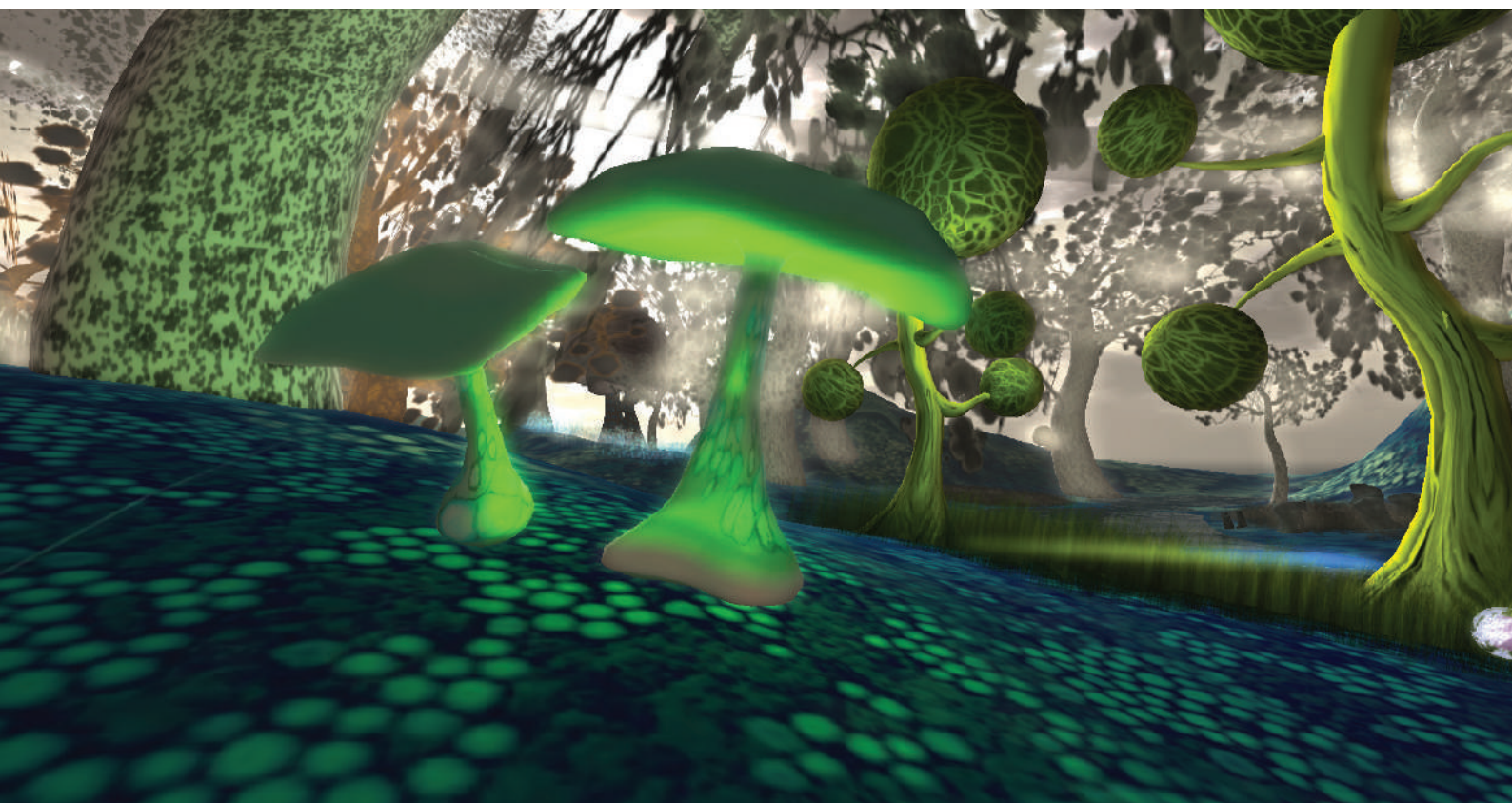


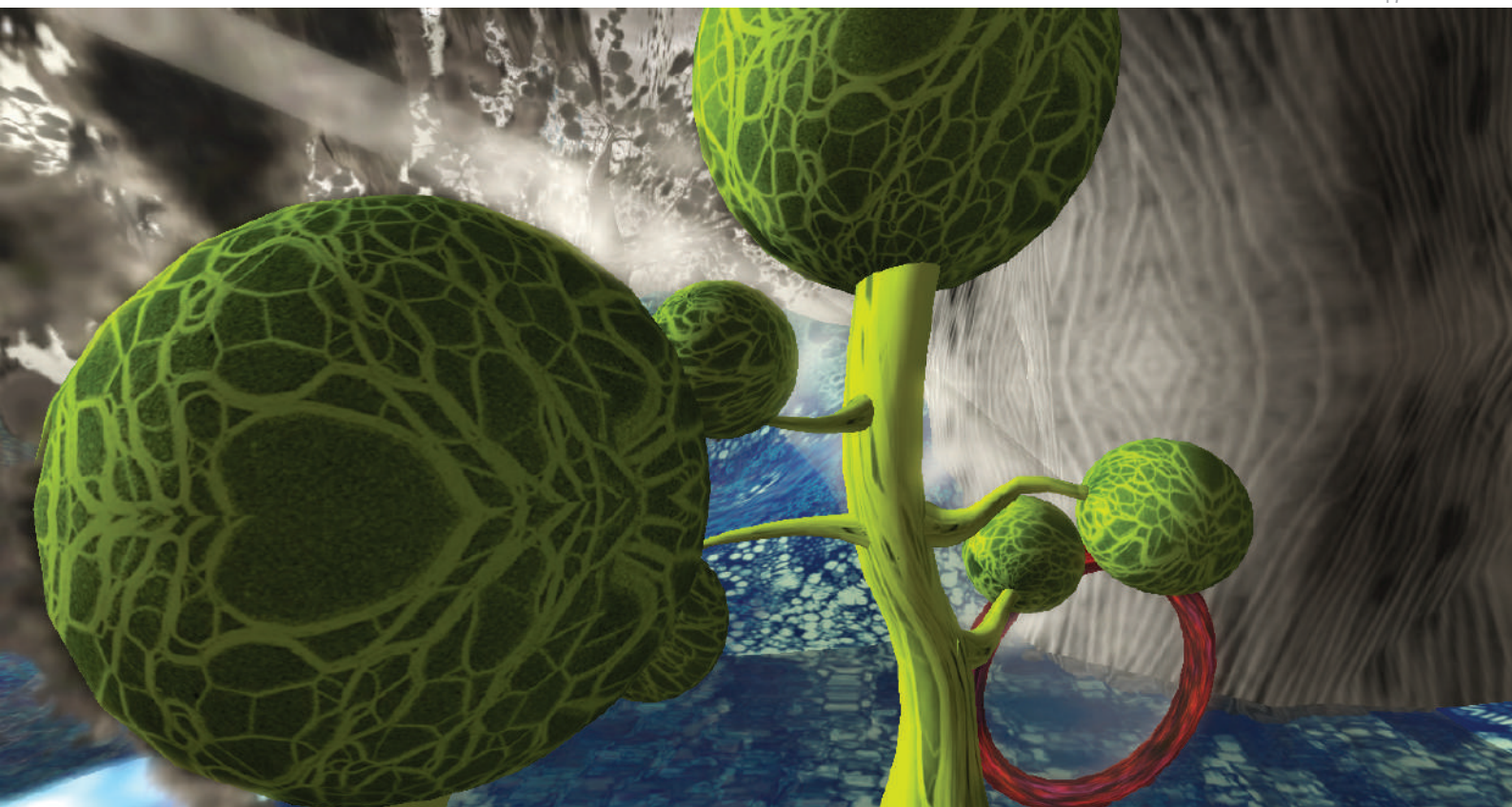
The geogenic nanoparticles: Opals and salt

In geochemistry, a nanoparticle is described as the intermediate between nuclei—which are forming and dissolving as a function of ionic concentration—and larger (micro)particle/composites. Nanoparticles—and their composite materials—can be understood as evolving objects strongly subject to the physicochemical and biological environments in which they occur. Thus, a nanoparticle cannot be understood without its context. For example, size and shape of the nanosized mineral determines the way in which (water) molecules layer around it **[A peek into the hidden world of nanosized minerals]** [18]. And this influences how the mineral interacts with its environment, including other nanoparticles, dissolved ions, and the surfaces of larger minerals and bacteria. Nanoparticles of many common mineral phases have been found in the wild, including ferric iron oxyhydroxides, such as goethite; transition metal sulfides, such as sphalerite; as well as less common minerals such as cerium oxide and gold. In addition, numerous common minerals are only found as nanomaterials, including ferrihydrite, akaganeite, mackinawite, and some manganese hydroxides. Naturally formed nanoparticles can be important components of geochemical cycles

in soils, groundwater, rivers, and lakes because they possess high surface areas for adsorption and reaction. Thus, nanosized minerals are important components of geochemical cycles; they are also key players in some of the biggest challenges facing scientists today: cleaning up contaminants left over from abandoned mines, or learning how to store carbon underground—where it can not contribute to climate change—requires a better understanding of how nanosized minerals participate in these processes. The ubiquity of tiny particles of minerals—mineral nanoparticles—in oceans and rivers, atmosphere and soils, and in living cells is providing scientists with new ways of understanding Earth’s workings **[“Nanominerals” influence Earth systems from ocean to atmosphere to biosphere]** [19].

In fact, our planet’s physical, chemical, and biological processes are influenced or driven by the properties of these minerals. Mineral nanoparticles play an important role in the lives of ocean-dwelling phytoplankton, for example, which remove carbon dioxide from the atmosphere. Phytoplankton growth is limited by iron availability. Iron in the

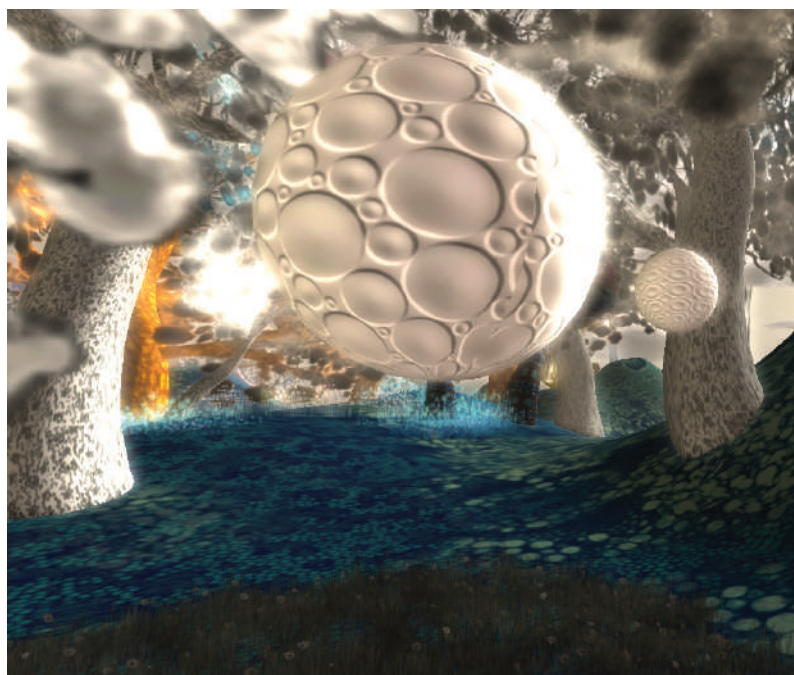


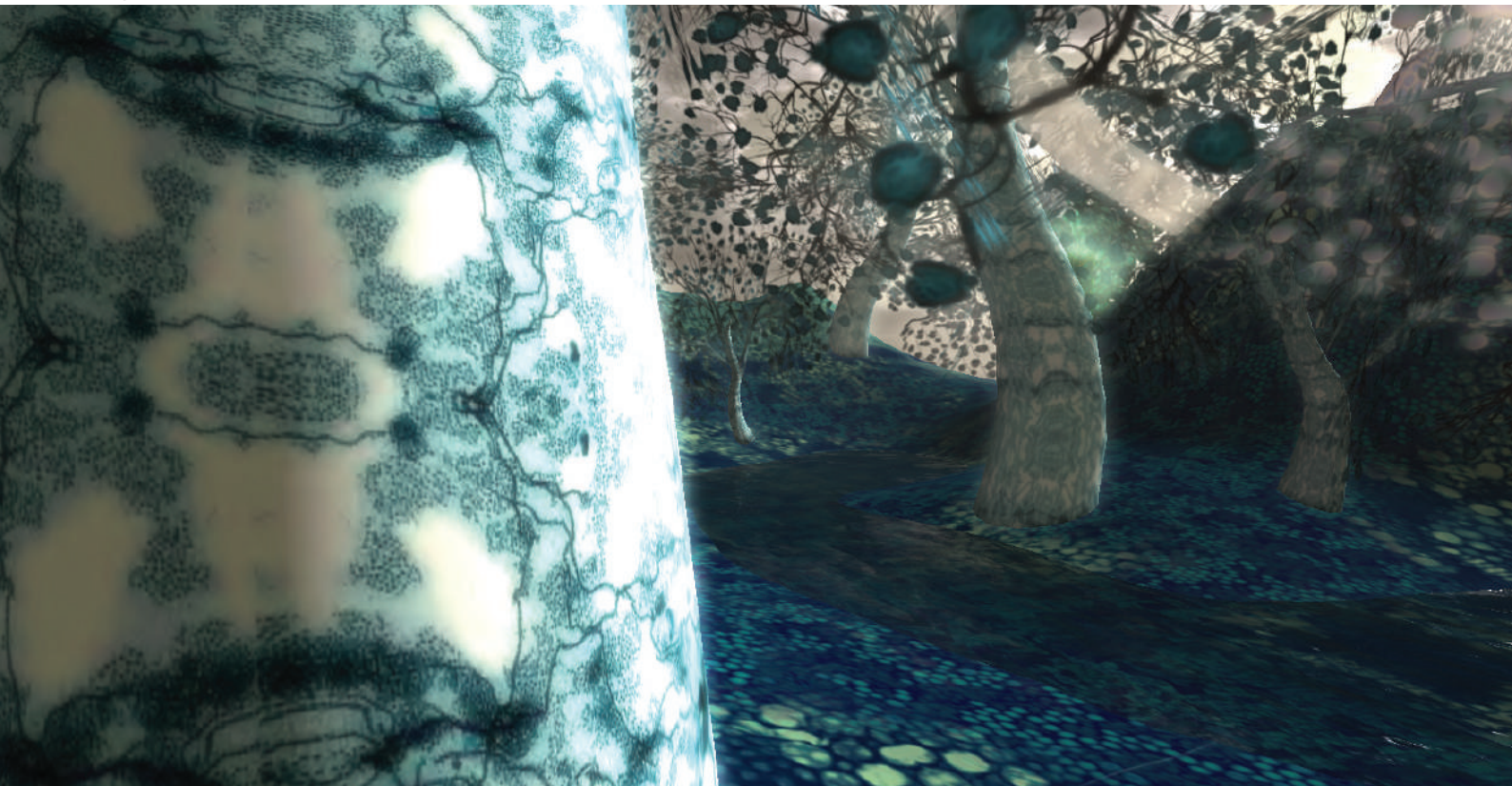


ocean is present, among others, in the form of mineral nanoparticles, supplied by rivers, glaciers, and deposition from the atmosphere. Nanoscale reactions resulting in the formation of phytoplankton biominerals, such as calcium carbonate, are important influences on oceanic and global carbon cycling. On land, nanometer-scale hematite catalyzes the oxidation of manganese, resulting in the rapid formation of minerals that absorb heavy metals in water and soils. The rate of oxidation is increased when nanoparticles are present. Conversely, harmful heavy metals may be dispersed widely, courtesy of nanominerals. Research at the Clark Fork River Superfund Complex in Montana found that a nanomineral was involved in the movement of lead, arsenic, copper, and zinc over hundreds of miles of the Clark River drainage basin. Nanominerals can also move radioactive substances. Research at one of the most contaminated nuclear sites in the world has shown that plutonium travels in local groundwater, carried by mineral nanoparticles. In the atmosphere, mineral nanoparticles impact heating and cooling. Such particles act as water-droplet-growth centers, which lead to cloud formation. The size and density of droplets influence solar radiation and cloud longevity, which in turn influence average global temperatures.

Nanoparticles may also be introduced into the environment as a consequence of human activities. For example, acid mine drainage, a legacy

of decades of mining activity, can introduce huge quantities of ferric iron oxyhydroxide nanoparticles into surrounding watersheds. Moreover, the intense interest in nanoparticles as industrial catalysts, chemical additives, and novel technologies suggests that the environmental impact of synthetic nanomaterials will only increase with time. Several groups have proposed that engineered nanomaterials may be harnessed for cleaning up contaminated sites, but the efficacy and impacts of such treatments have yet to be fully established [Introduction to Nanogeoscience] [20].





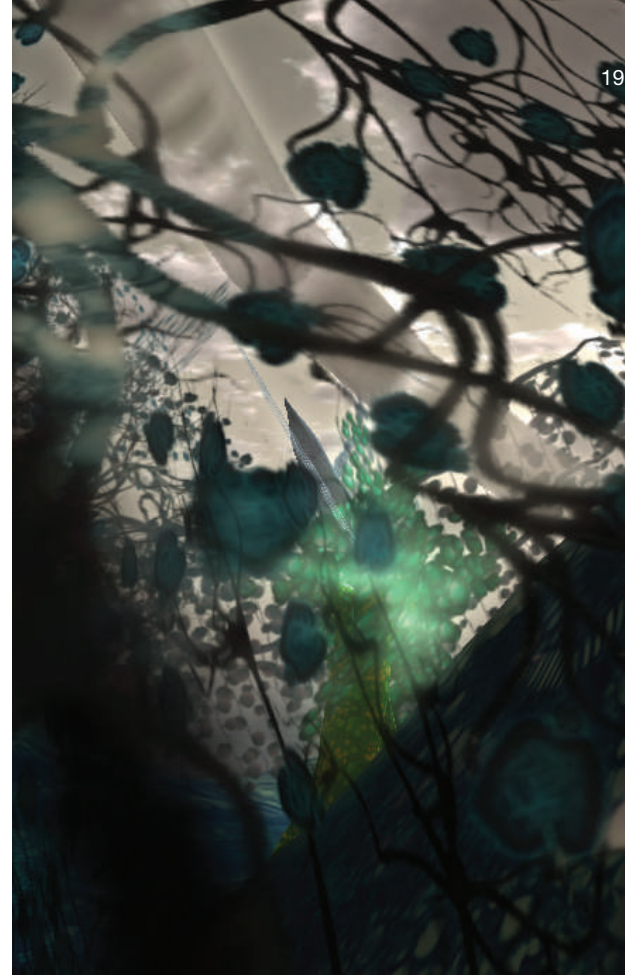
Interestingly, NPs of silver are increasingly being found in the environment—and in environmental science laboratories. Because they have a variety of useful properties, especially as antibacterial and antifungal agents, silver nanoparticles are increasingly being proposed in a wide variety of industrial and consumer products. This occurrence, in turn, has raised concerns about what happens to the NPs once they are released into the environment. Now a new research paper adds an additional wrinkle: Nature may be making silver nanoparticles on its own [**New Evidence for Natural Synthesis of Silver Nanoparticles**] [21]. Given a source of silver ions, naturally occurring humic acid, a mild and ubiquitous reducing agent, will synthesize stable silver nanoparticles. “Humic acid” is a complex mixture of many organic acids that are formed during the decay of dead organic matter. Although the exact composition varies from place to place and season to season, humic acid is ubiquitous in the environment. The team mixed silver ions with humic acid from a variety of sources at different temperatures and concentrations and found that acids from river water or sediments would form detectable silver nanoparticles at room temperature in as little as two to four days. Moreover, the humic acid appears to stabilize the nanoparticles by coating them and preventing the nanoparticles from clumping together into a larger mass of silver. Metallic nanoparticles have characteristic colors that are a direct consequence of their size. Silver nanoparticles appear as yellowish brown. “This caught us

by surprise because a lot of our work is focused on how silver nanoparticles may dissolve when they’re released into the environment and release silver ions. Many biologists believe the toxicity of silver nanoparticles, the reason for their use as an antibacterial or antifungal agent, is **due to their high surface area that makes them an efficient source of silver ions. This creates the idea that there may be some sort of natural cycle—detoxification—, returning some of the ions to nanoparticles.**” It also helps explain the discovery, over the past few years, of silver nanoparticles in locations like old mining regions that are not likely to have been exposed to man-made nanoparticles, but which do have significant concentrations of silver ions present.

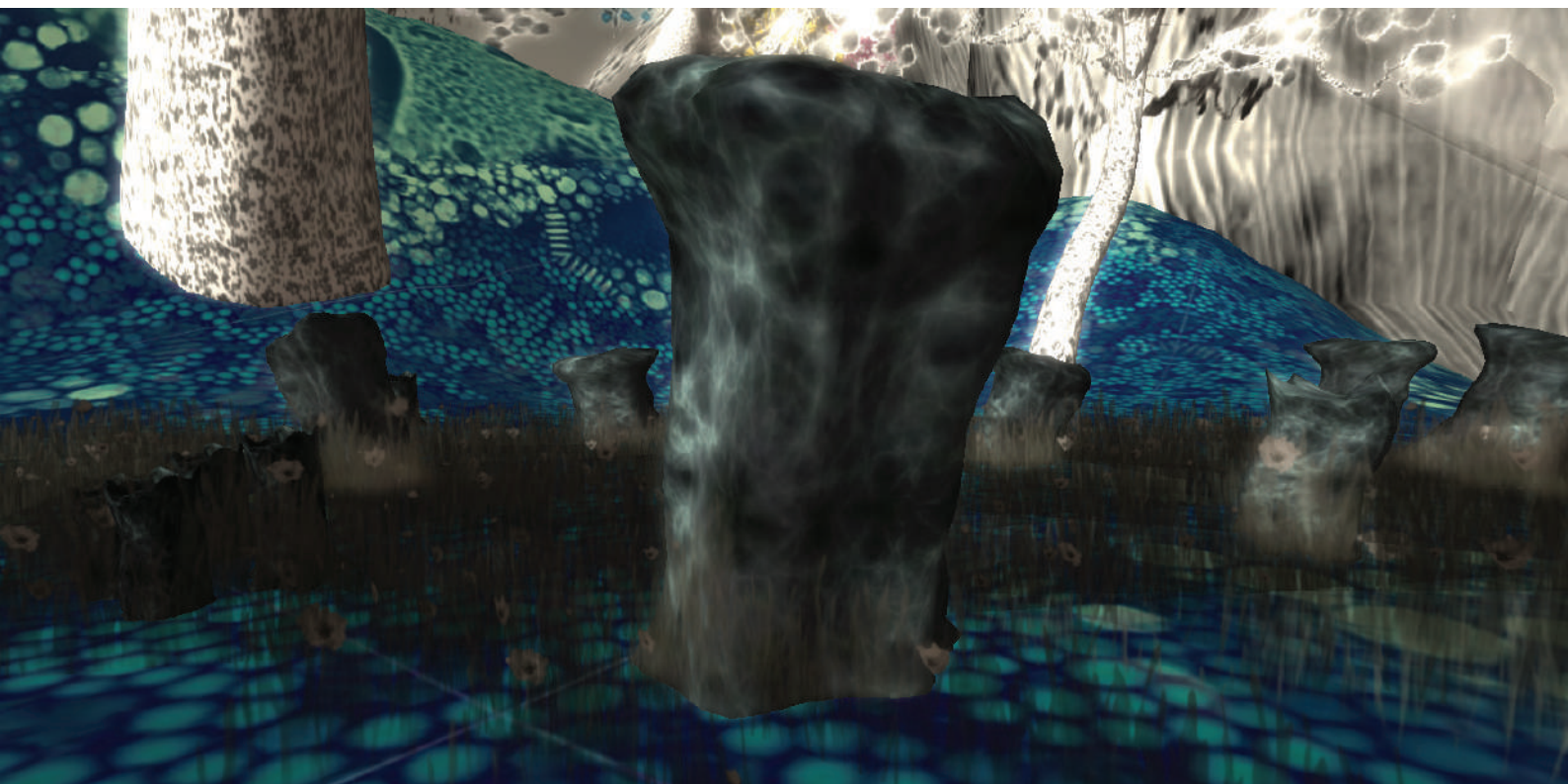
Far beyond this Earth, mysterious expanding ice crystals in the moons of Saturn and Neptune may be of interest to future developers of micro-electronics. Neutron scattering has revealed that methanol crystals that may be found in outer solar system ‘ice lavas’ have unusual expansion properties [**Study of volcanoes in the outer solar system produces unexpected bonus for nanotechnology**] [22]. Structural changes have been observed in methanol crystals over a range of temperatures and pressures. When heated at room pressure the crystals would expand enormously in one direction whilst shrinking in the other two dimensions. However when heated under an even pressure they expanded in two directions, whilst compressing

in the third. Methanol monohydrate is a known constituent of outer-solar-system ice. Whilst these results form the next step towards understanding outer-solar-system volcanic activity, the discovery is also of significant interest for material scientists developing nanotechnology. The predictable expansion in a particular direction under pressure makes these crystals good candidates for nanoswitches, where their shape-shifting properties can be used like a microscopic, pressure-controlled valve to direct the flow of electricity.

On Earth, volcanoes do not produce ice lava but they do produce a catalyst [**Volcanoes and nanotechnology**] [23] which promotes the direct synthesis of carbon nanotubes with volcanic rock. Since their discovery in the early 1990s, carbon nanotubes and carbon nanofibers—tiny structures made of pure carbon—have been used in a wide variety of applications. The naturally occurring iron oxide particles in lava make it an effective natural catalyst, possibly smoothing the way to a more efficient production method for commercial catalysts. Lava rock is extremely porous and contains large quantities of finely divided iron oxide nanoparticles, and this is just what is needed for the synthesis of these tiny carbon structures. The geological aspect of this reaction is also quite interesting: if a carbon



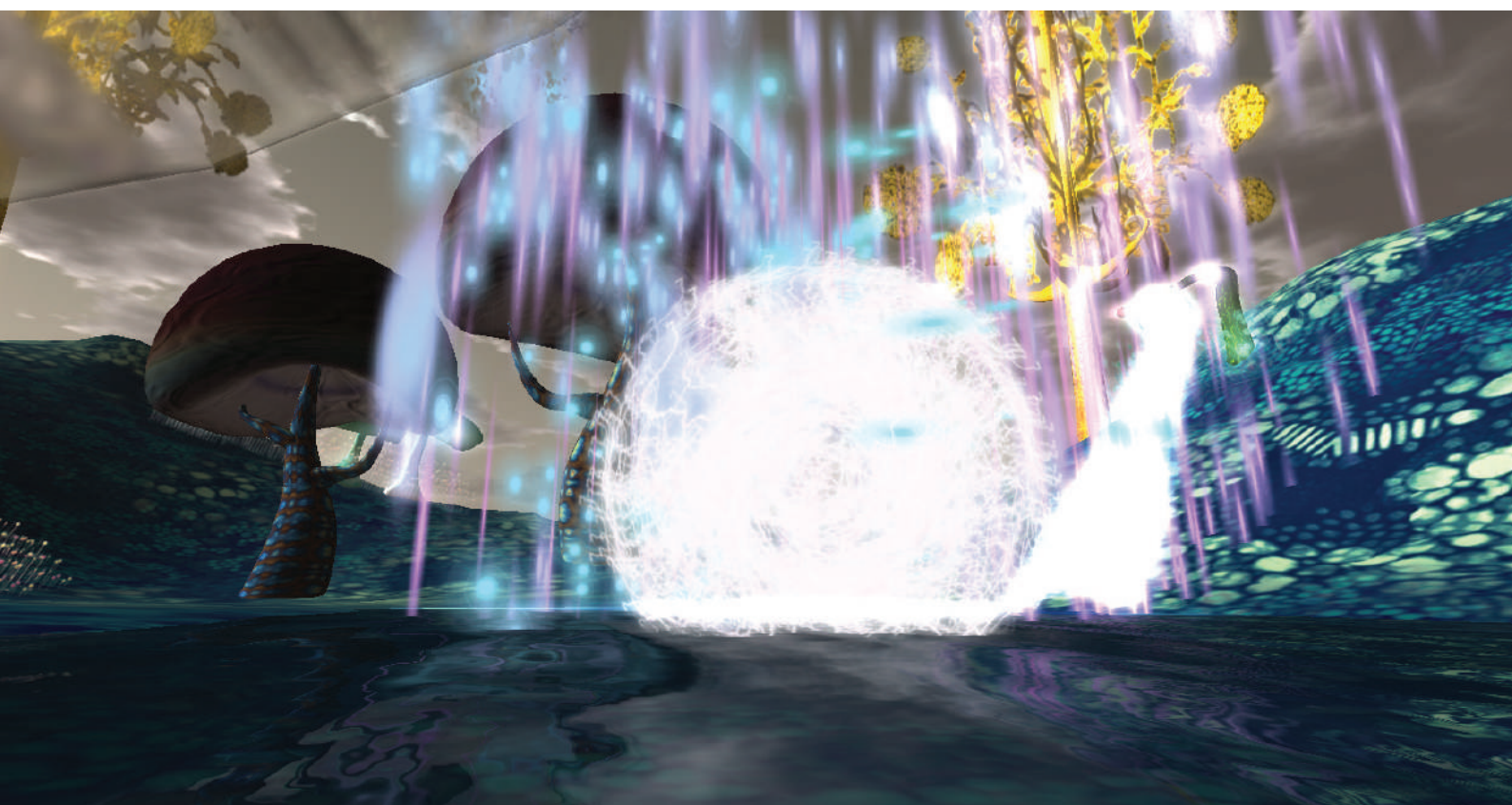
source is present, carbon nanotubes and fibers can be formed on minerals at relatively moderate temperatures. Volcanoes produce gases such as methane and hydrogen. Could these forms of carbon already have been generated on Earth millions of years ago? Hydrogen, carbon oxides, and metallic iron are also present in interstellar space—could these little tubes and fibers be produced in space?

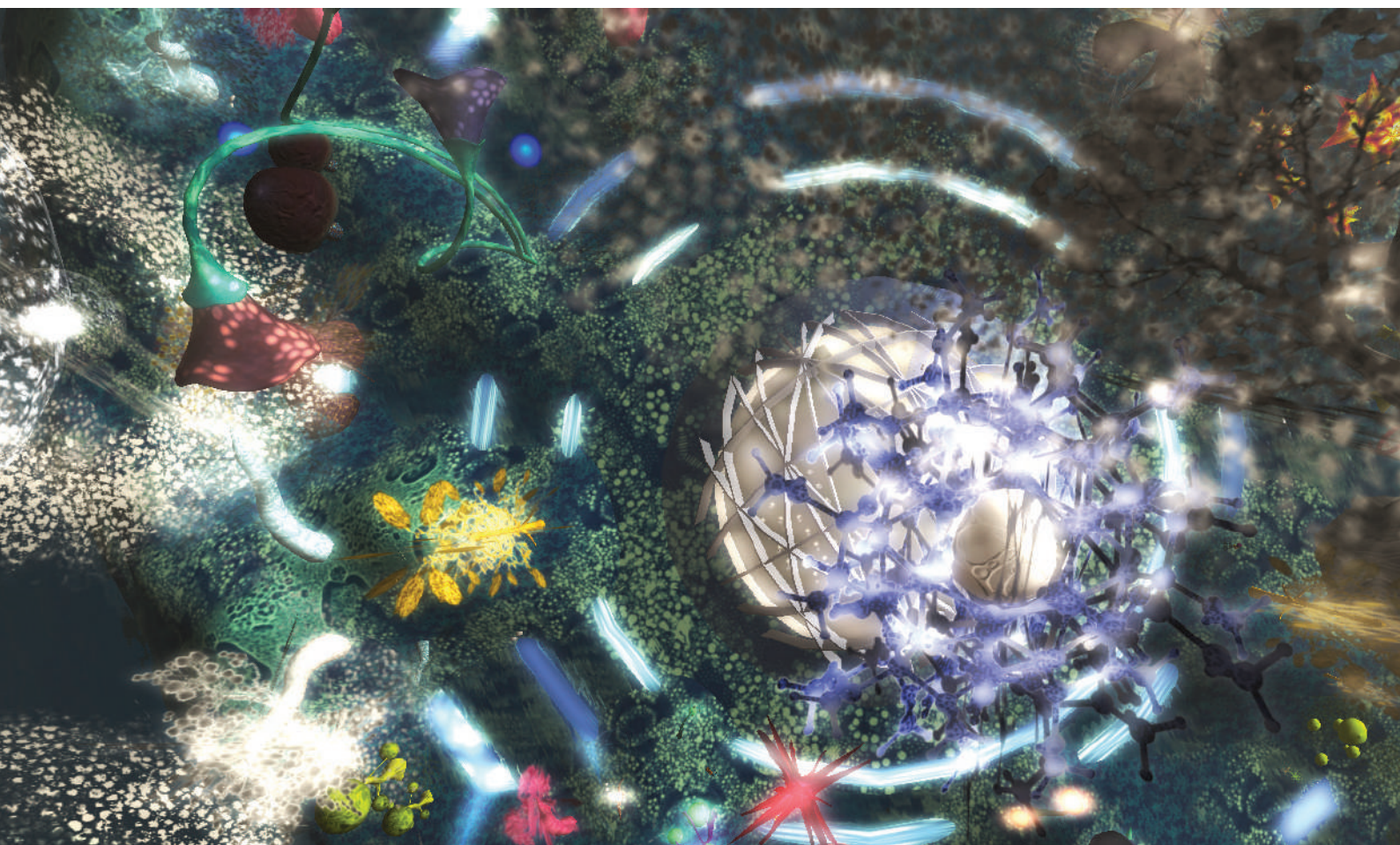


The cosmogenic nanoparticles: Carbon nanotubes and fullerenes

Astronomers using NASA's Spitzer Space Telescope discovered carbon molecules known as "buckyballs", the largest molecules known to exist, in space for the first time last year [NASA telescope finds elusive buckyballs] [24]. Unexpectedly, carbon balls were found in a planetary nebula named Tc 1. Planetary nebulas are the remains of stars, like the sun, that shed their outer layers of gas and dust as they age, and burn and lose mass and gravity. A compact, hot star, or white dwarf, at the center of the nebula illuminates and heats these clouds of shed material. In 1970, Japanese professor Eiji Osawa predicted the existence of buckyballs, but they were not observed until lab experiments in 1985. Researchers simulated conditions in the atmospheres of aging, carbon-rich giant stars, in which chains of carbon had been detected. Surprisingly, these experiments resulted in the formation of large quantities of buckyballs. The molecules have since then been found on Earth in candle soot, layers of rock, and meteorites. Sir Harry Kroto, who shared the 1996 Nobel Prize in chemistry with Bob Curl and Richard Smalley for the discovery of buckyballs, said, "This most exciting breakthrough provides convincing evi-

dence that the buckyball has, as I long suspected, existed since time immemorial in the dark recesses of our galaxy." Another team of astronomers, using the same telescope, has reported the first extragalactic detection of the C70 fullerene molecule, and the possible detection of planar C24 ("a piece of graphene") in space. They describe how collisional shocks powered by the winds from old stars in planetary nebulae could be responsible for the formation of fullerenes and graphene. Fullerenes, or buckyballs, are well known from laboratory work on earth, and display many interesting and important properties. Fullerenes consist of carbon atoms arranged in a three-dimensional sphere similar to the geodesic domes popularized by Buckminster Fuller. The C70 fullerene can be compared with a rugby ball, while C60 is compared to a soccer ball. Graphene is a flat sheet of carbon atoms, one atom thick, which has extraordinary strength, conductivity, elasticity, and thinness, and is cited to be the thinnest known substance. Planetary nebulae originate from stars similar to our sun that have reached the end of their lives and are shedding shells of gas into space. In this case, the planetary nebulae are located in the Magellanic Clouds, two

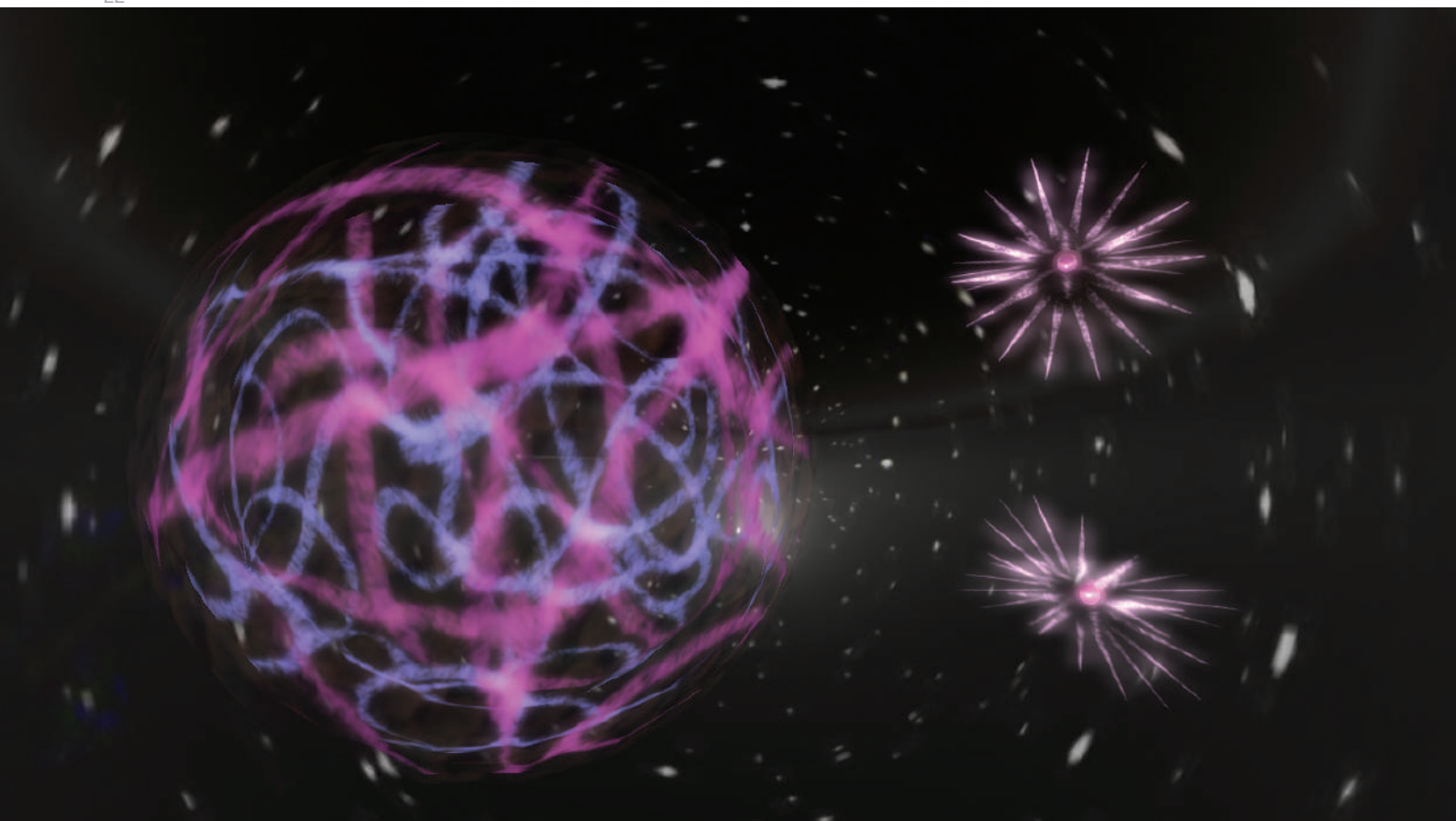




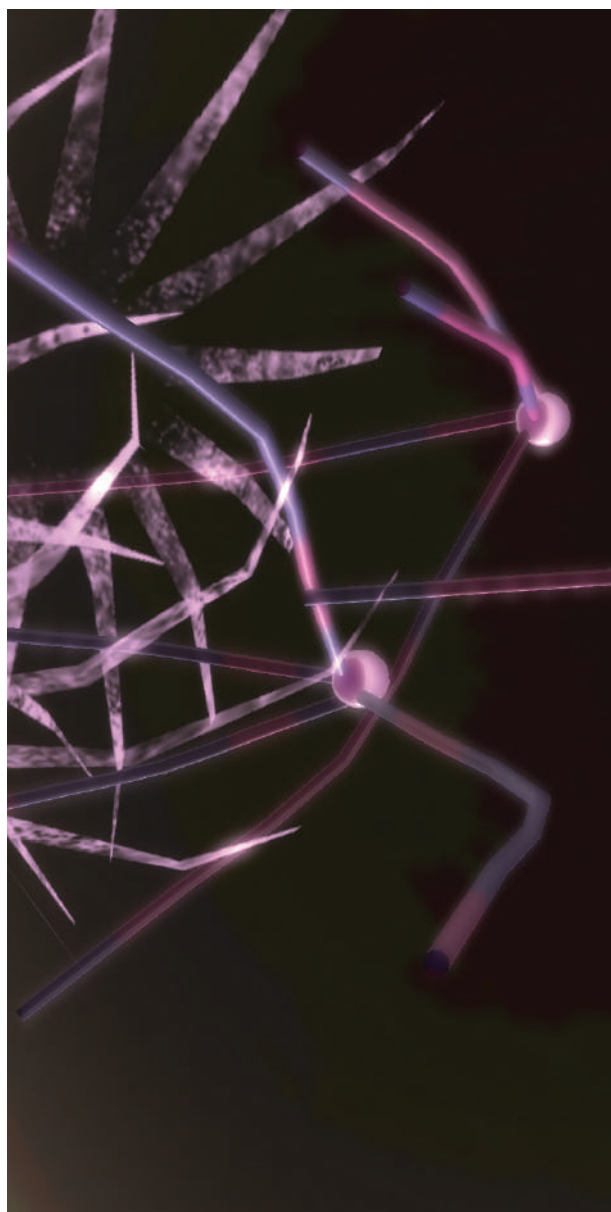
satellite galaxies to our own Milky Way, which are best seen from the Southern Hemisphere. At a distance from the Magellanic Clouds, the planetary nebulae appear as small fuzzy blobs. The team has proposed that fullerenes and graphene are formed from the shock-induced (i.e., grain-grain collisions) destruction of hydrogenated amorphous carbon grains. Such collisions are expected in the stellar winds emanating from planetary nebulae. What is particularly surprising is that the existence of these molecules would not depend on the stellar temperature, but on the strength of the wind shocks. All these carbon nanostructures become especially exciting if we consider that buckyballs from outer space may have provided the seed for life on Earth [**Buckyballs from outer space provided seeds for life on Earth?**] [25]. Fresh from finding buckyballs around an aging star, NASA's Spitzer Space Telescope detected these intriguing, miniature soccer-ball-shaped molecules in interstellar space, also for the first time. With these new results, the buckyball can claim the record for the largest molecule ever discovered floating between

the stars. The unique properties of buckyballs that have made these rounded particles such a hot area of research here on Earth also offer up some exciting possibilities for cosmic chemistry. Hints of interstellar buckyballs had first come in 1994, when detected absorption lines were attributed to buckyballs missing an electron. Then, in 2004, colleagues serendipitously detected two light signatures indicative of the faceted mini-globes. The researchers knew they had caught a buckyball for sure this time around when they saw a predicted third signature in infrared light from the nebulae.

They detected buckyballs around a fourth dying star in a nearby galaxy in staggering quantities—the equivalent in mass to about 15 of our moons. Scientists have speculated in the past that buckyballs, which can act like cages for other molecules and atoms, might have carried to Earth the substances that kick-started life. I am still trying to imagine how to fit such complex life building-blocks as amino acid molecules into the sub-nanometric space inside C60-C70 buckyballs, but the hypothesis is nice.



But not only carbon nanostructures were found. Scientists have also identified the microscopic shrapnel of a nearby star that exploded just before or during the birth of the solar system 4.5 billion years ago. Faint traces of the supernova, found in a meteorite, account for the mysterious variations in the chemical fingerprint of chromium found from one planet and meteorite to another [**Supernova nanoparticles found in meteorite**] [26]. Scientists formerly believed that chromium 54 and other elements and their isotopic variations became evenly spread throughout the cloud of gas and dust that collapsed to form the solar system. Scientists have known for four decades that a supernova probably occurred approximately 4.5 billion years ago, which possibly triggered the birth of the sun. Their evidence came in the form of traces of aluminum 26 and iron 60, two short-lived isotopes found in meteorites but not on Earth. These isotopes could have come from a type II supernova, caused by the core-collapse of a massive star. “It seems likely that at least one massive star contributed material to the solar system, or what was going to become the solar system, shortly before its birth. Cosmochemists have sought the carrier of chromium 54 for the last 20 years but only recently have instrumentation advances made it possible to find it in chromium 54-enriched nanoparticles (less than 100 nm in diameter).”

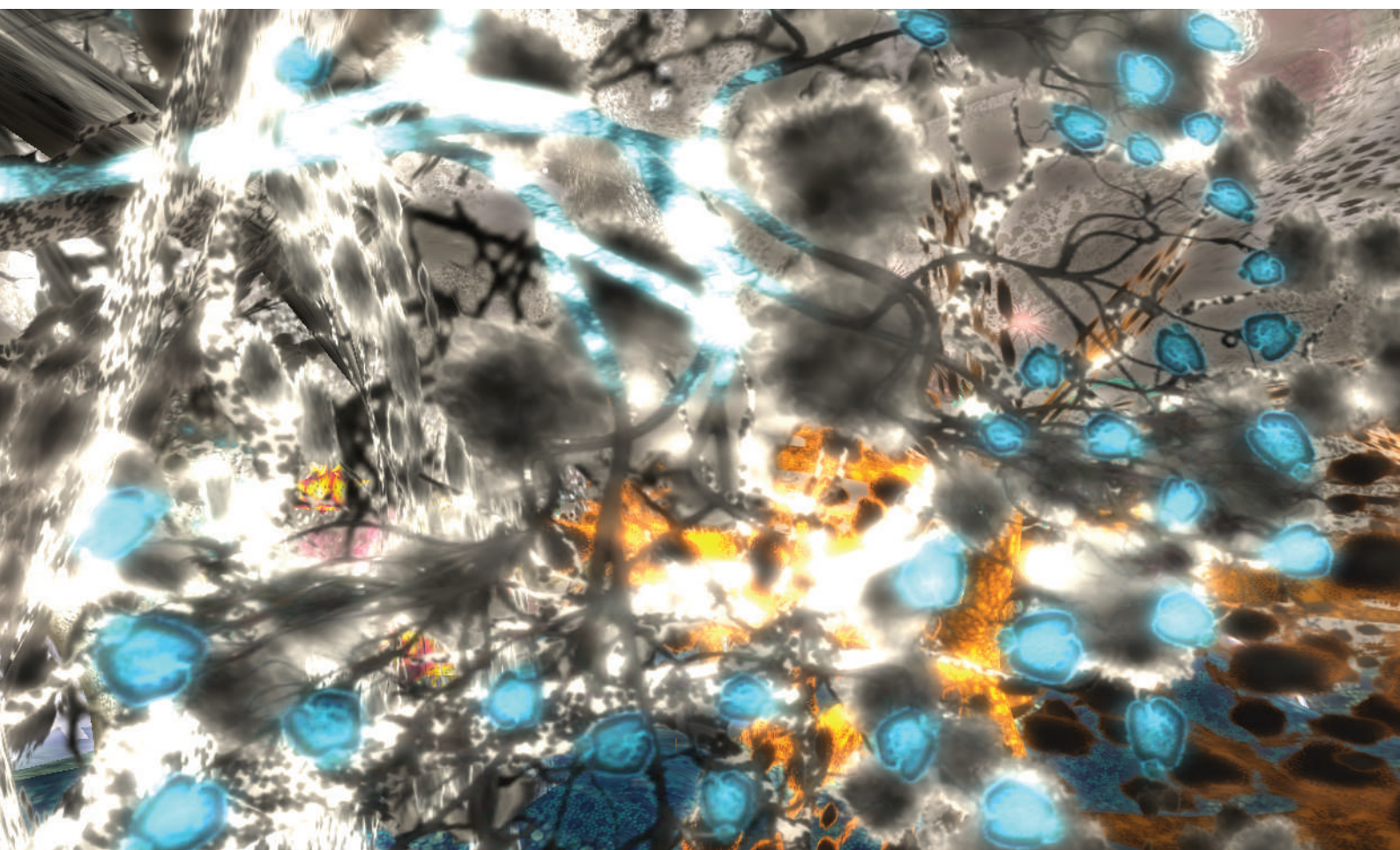


The unintended nanoparticles: Burning paraffin makes diamond

The famous scientist Michael Faraday in his celebrated 19th century lectures on “The Chemical History of a Candle” said in an 1860 address to the light: “You have the glittering beauty of gold and silver, and the still higher lustre of jewels, like the ruby and diamond; but none of these rival the brilliancy and beauty of flame. What diamond can shine like flame?”. For centuries, the flickering flame of a candle has generated comparisons with the twinkling sparkle of diamonds, but new research has discovered the likeness owes more to science than to the dreams of poets: tiny diamond particles exist in candle flames **[Candle flames contain millions of tiny diamonds]** [27]. Around 1.5 million diamond nanoparticles are created every second in a candle flame as it burns. In fact, a candle flame contains all four known forms of carbon. At the bottom of the flame, hydrocarbon molecules are converted into carbon dioxide that is found the top of the flame. But the process in between remained a mystery. Now both diamond nanoparticles and fullerenic particles have been observed

in the center of the flame, along with graphitic and amorphous carbon.

But not all the results of burning organic matter are nice. Atmospheric (micro and nano) particles impact health **[Atmospheric nanoparticles impact health, weather]** [28]. Combustion microparticles are atmospheric materials that can very visibly affect both weather patterns and human health all over the world—and not in a good way; in addition to the observed deleterious effects of breathing car exhaust gases, it is also well known that micrometric particles irritate the lung. Sometimes, nanometric particles are generated that rapidly grow by coalescence into micrometric ones. When this happens, the nanoparticles scatter light back into space, and that definitely has a cooling effect—sort of a reverse ‘greenhouse effect. Such particles can form near areas that have petrochemical plants, which normally also have high levels of aerosols from traffic emissions and other numerous factories.



The unnoticed nanoparticles:

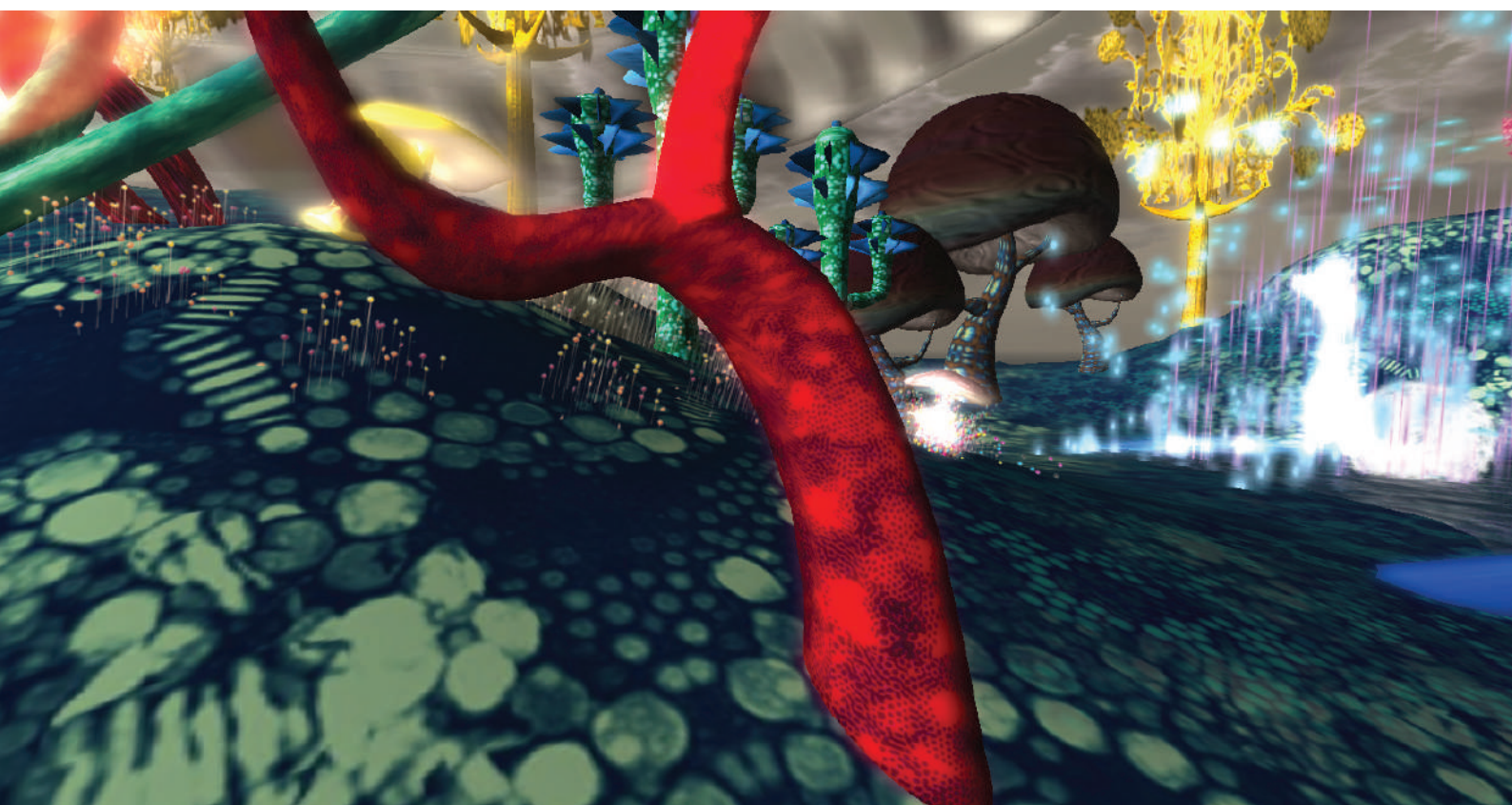
Cosmetics and colored glass in the church

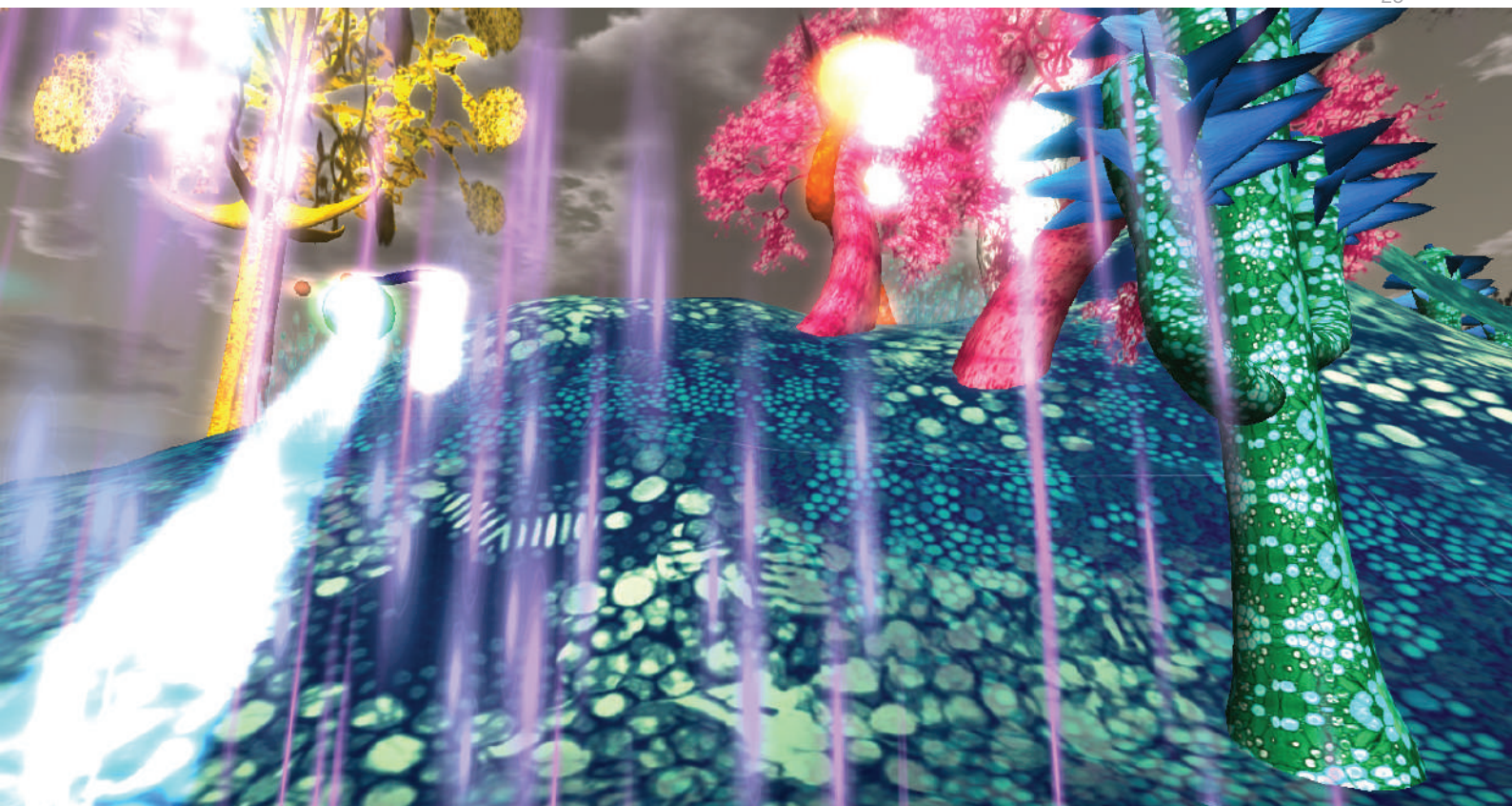
In fact, even with all the fine cosmetics and precise emulsions we have now, already from over 2000 years ago, an ancient dyeing process for blacking hair is a remarkable illustration of synthetic nanoscale biomineralization **[2000 years ago...]** [29], as the mixture of oil and clays employed by ancient Egyptians led to the synthesis of 5-nm PbS quantum dots. And when we painted the walls of the caves, we also painted ourselves, most likely, and it would be in this way that the 5300 years old Oetzi mummy would have got TiO_2 NPs in the alveoli, from white paint and tattoos.

Consider sabers from Damascus that date back as far as 900 AD. They are strong and sharp, made from a type of steel called *wootz*. Their blades bear a banded pattern thought to have been created as the sword was annealed and forged **[Carbon nanotube... sword!]** [30]. But the secret of the swords' manufacture was lost in the 18th century. Electron-microscope pictures of the swords showed that *wootz* has a microstructure of nanometer-sized tubes, just like carbon nanotubes that are used in modern technologies for their lightweight strength. This structure was simply what one got when one water-hardened iron heated in carbon flames.

Colored glass is full of NPs as a result of mixing inorganic salts (gold for red, copper for blue, non-radioactive uranium for yellow) with molten glass. Additionally, stained glass windows that are painted with gold purify the air when they are lit up by sunlight, a team of scientist has discovered **[Air-purifying church windows early nanotechnology]** [31]. Tiny particles of gold, energized by the sun, were able to destroy airborne pollutants like volatile organic chemicals. Gold, when in very small particles, becomes very active under sunlight. The electromagnetic field of the sunlight can couple with the oscillations of the electrons in the gold particles and creates a resonance (surface plasmon resonance). Then the electromagnetic field on the surface of the gold nanoparticles can be enhanced by up to hundred times, which breaks apart the pollutant molecules in the air. It is worth noting that this type of mixture of glass and metallic (and oxide) nanoparticles decorates many temples and historical buildings across the world.

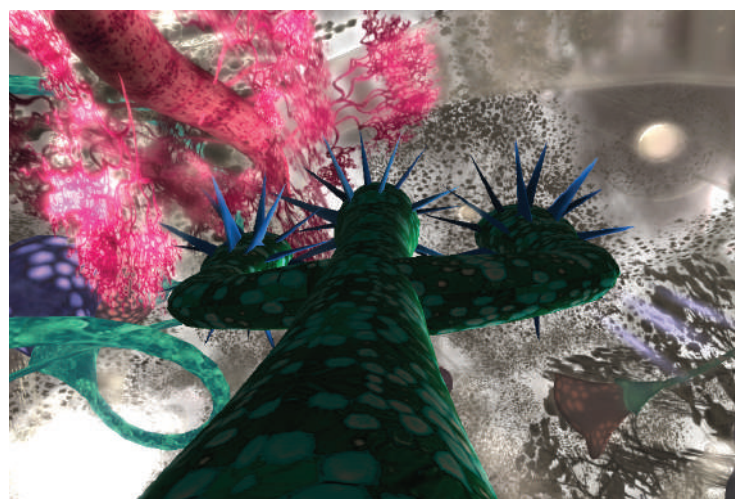
It turns out, researchers say, that nanoparticles have been fabricated and in contact with humans for a long, long time. Also silver nanoparticles existed before the term nanosilver was coined

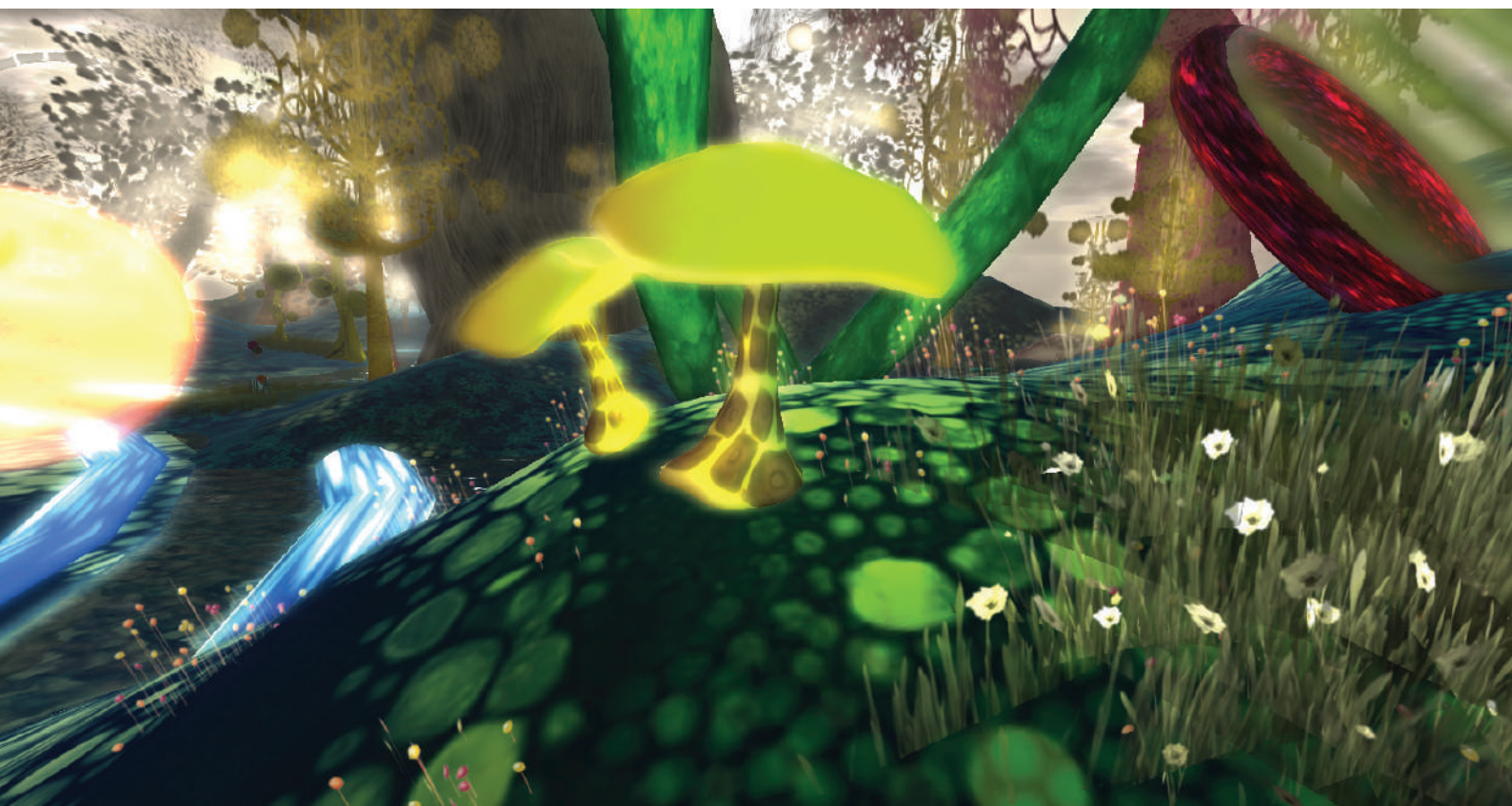




[120 Years of Nanosilver History] [32]. Nanosilver has been used in various products for over a hundred years. The antimicrobial effects of minute silver particles, which were then known as “colloidal silver”, were known from the earliest days of use. Silver particles with diameters of 7 to 9 nm were mentioned as early as 1889. They were used in medications or as biocides to prevent the growth of bacteria on surfaces, for example in antibacterial water filters or in algaecides for swimming pools, known as “colloidal silver” in those days. When “colloidal silver” became available on the market in large quantities in the 1920s it was the topic of numerous studies and subject to appropriate regulation by the authorities: For a given volume, nanoparticles have a much greater surface area than bulk silver metal, so they are frequently much more reactive. In addition, even in small quantities, nanosilver produces more silver ions than does solid silver. These silver ions are toxic to bacteria. One concern arises when nanosilver arrives at wastewater-treatment plants. Currently there are hundreds of products in circulation which contain silver nanoparticles. Examples include cosmetics, food packaging materials, disinfectants, cleaning agents and—not least—antibacterial socks and underwear. Every year some 320 tonnes of nanosilver are used worldwide, some of which is released into wastewater, thus finding its way into natural water recirculation systems where it will likely arrive in its ionic form. From there it quickly reacts with

Cl, Br, or S, becoming an insoluble, inert material. It may also become Ag_2O on reaction with O_2 but it prefers to react with S. In fact, silver will first react with O_2 and then with S. The implications of the newest studies on nanosilver in sewage-treatment plants are uncertain, however, more than 90% remains bound in the sewage sludge in the form of silver sulfide, a substance which is extremely insoluble and orders of magnitude less poisonous than free silver ions. Similar happens with Cl- and the insoluble AgCl salts. It apparently does not matter what the original form of the silver in the wastewater was, whether as metallic nanoparticles, as silver ions in solution, or as precipitated insoluble silver salts. *“As far as the environmental effects are concerned, it seems that nanosilver in consumer goods is no different than other forms of silver and represents only a minor problem for eco-systems”* (A commentary by Bernd Nowack) [33]. And even





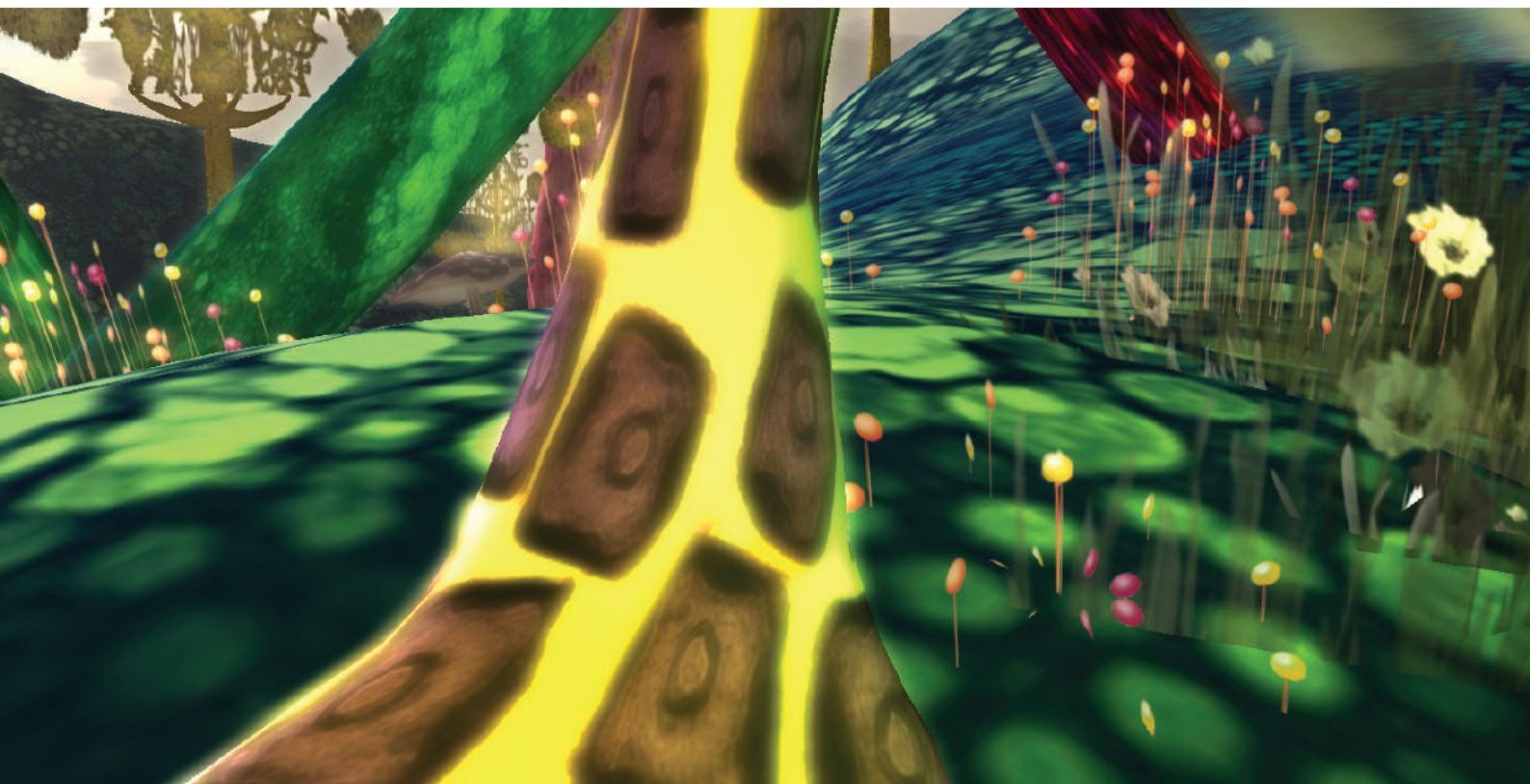
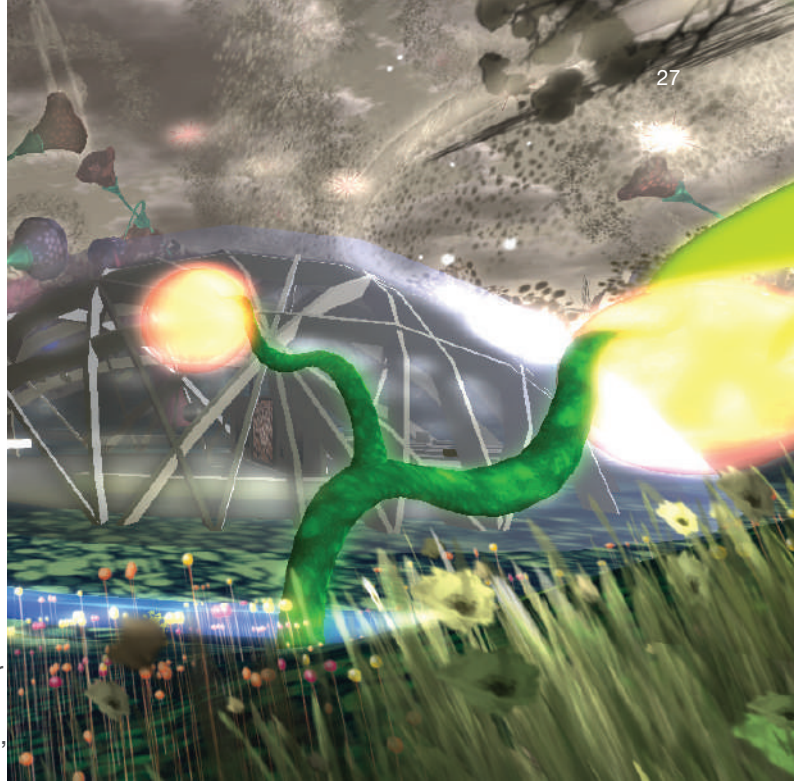
more. If you've ever eaten from silverware or worn copper jewelry, you've been in a perfect storm in which nanoparticles were dropped into the environment [**Challenging conventional thinking on the reactivity of nanoparticles**] [34]. Now, with the help of high-powered transmission electron microscopes, chemists have captured views of minuscule metal nanoparticles naturally being created by silver articles such as wire, jewelry, and eating utensils in contact with other surfaces. Researchers found that silver nanoparticles deposited on the surface of their electron microscope slides began to transform in size, shape, and particle population within a few hours, especially when exposed to humid air, water, and light. Similar dynamic behavior and new nanoparticle formation was observed when the study was extended to look at macrosized silver objects such as wire or jewelry. These findings show that nanoparticle 'size' may not be static, especially when particles are on surfaces. In addition, the generation of nanoparticles from objects that humans have been in contact with for millennia suggests that humans have been exposed to these nanoparticles throughout time. These findings represent a general phenomenon for metals readily oxidized and reduced under certain environmental conditions.

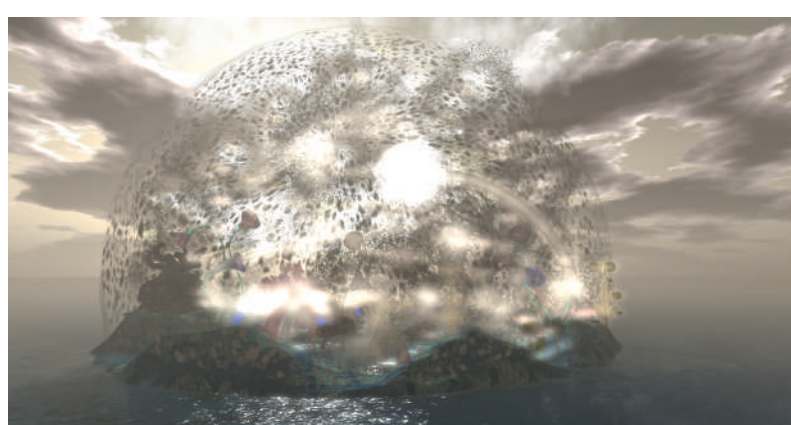
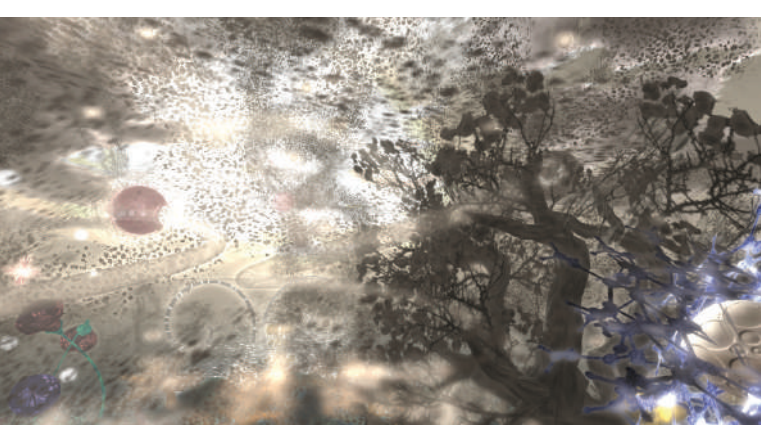
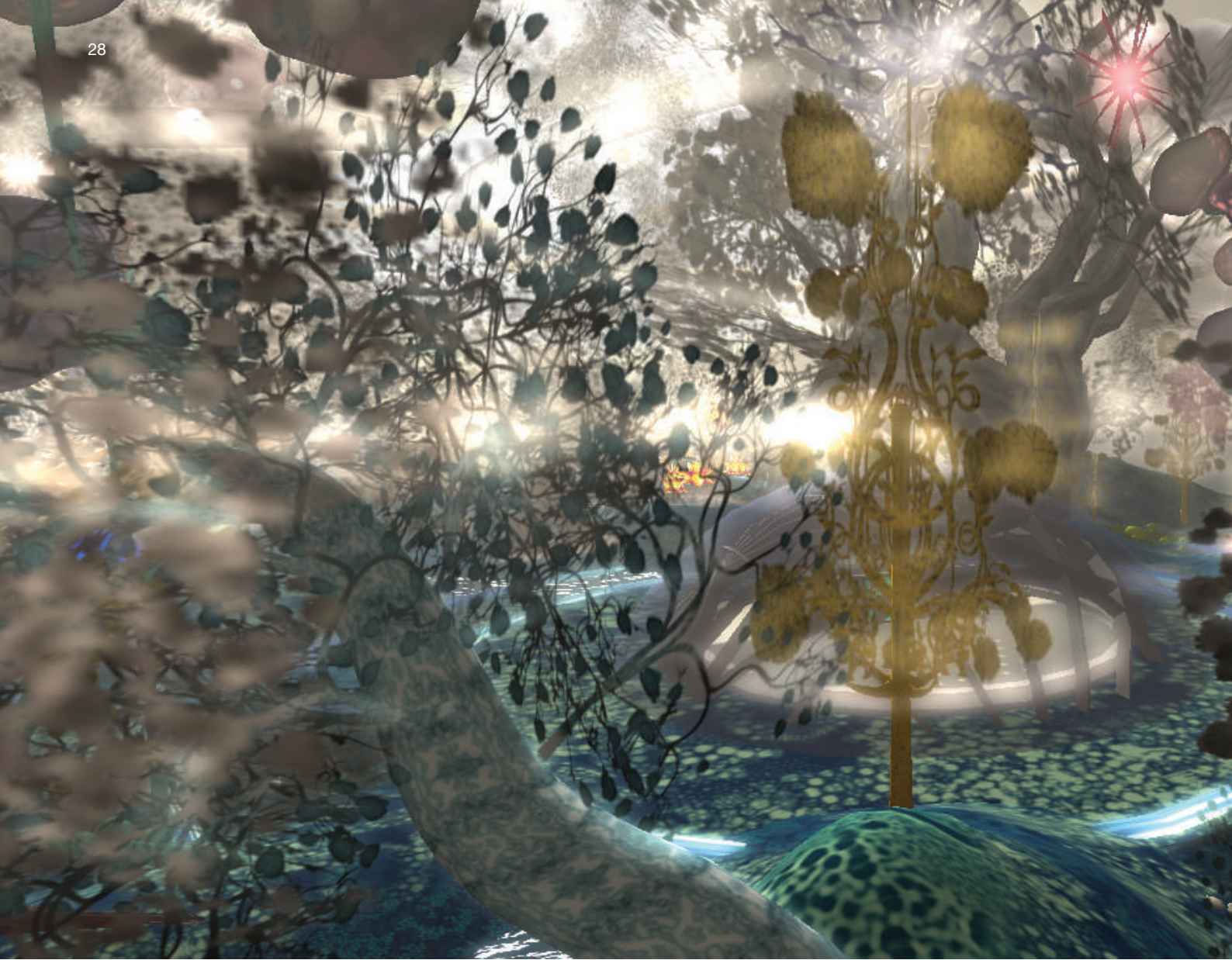
Maybe this learning from nature to design advanced tools can be maintained, as natural nanopolymers may be used to carry drugs [**Natural nanopolymers used as drug carriers**] [35]: Nanocellulose drug carriers were produced by Iranian researchers from Islamic Azad University in association with their colleagues from Northern Carolina University of the US in a bid to fight various types of illness-causing bacteria such as those resistant to antiseptics. Natural nanopolymers, among which nano-cellulose is one of the most important, consist of crystalline and biological nanoparticles. Cellulose nanoparticles are chemically neutral but biologically degradable and compatible with the human body. Cellulose nanoparticles have applications in numerous industries such as polymer, food, nanoelectronics, paper fabrication, filters for chemical materials and gas neutralization, textiles, and so forth. However, their application in medicine and as drug carriers has not yet been developed, nor the use of benign bacteria virus into an engineering tool for assembling structures that mimic collagen [**The virus is emerging as a nanoscale tool**] [36], one of the most important structural proteins in nature, nor the use of its capsid to administer safe vaccines (since there is no virus but only its coat).

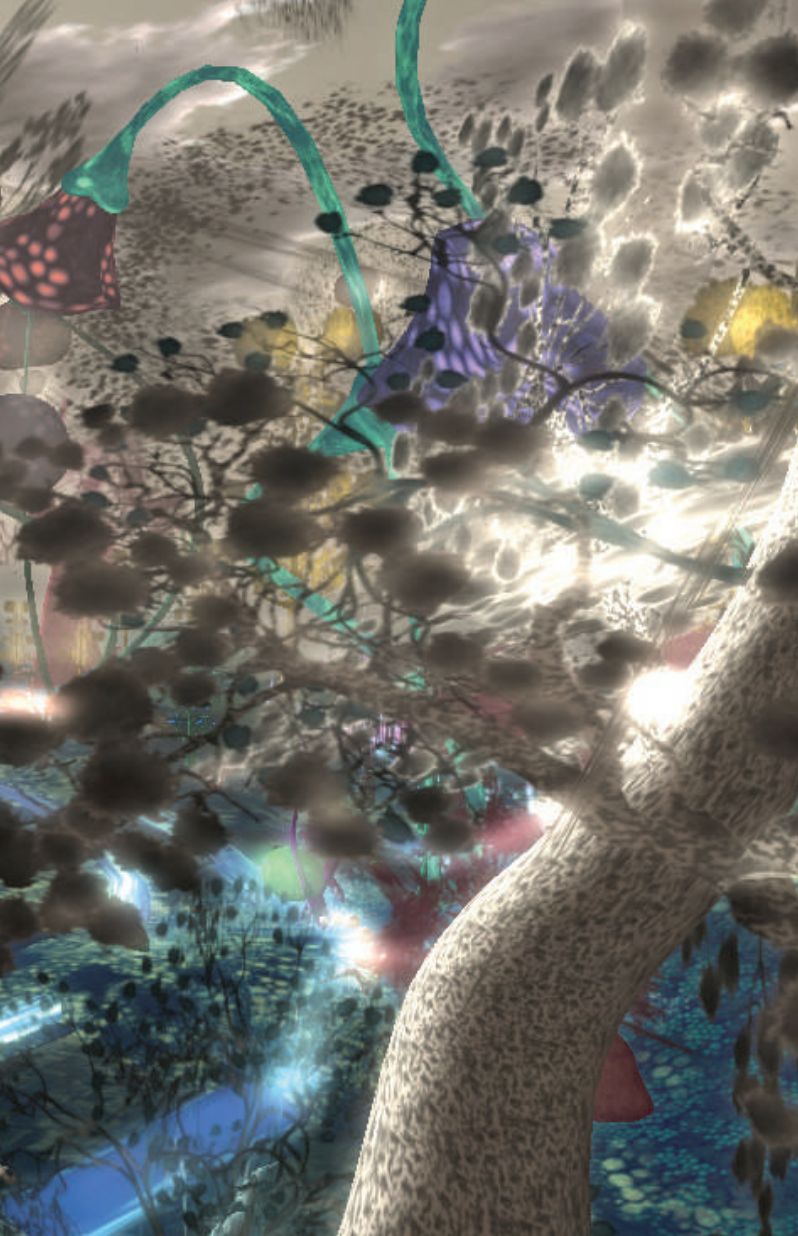
Finally, today, the application of nanotechnology in food and its concerns are rising fast. Recently the European Food Safety Authority (EFSA) was looking for laboratories that can detect nanoparticles in food samples. This task is going to be difficult: first because of the complex matrix that food is, and second due to its natural nanometric nature, for example, milk is a model colloid with NPs suspended in it, or including food utensils, as silver spoons, that yield silver NPs in soups, or carbon NPs in carbohydrate-based food such as caramels, bread, jaggery, flakes, and biscuits [Nanoparticles in caramels, sugar, bread...] [37].

For food, two nanotechnology-proposed improvements are especially appealing. One is to nanostructure food, for example, salt. Salt is tasted on receptors on cells in the mouth; the taste interaction is between the surface of the grain and the molecular receptor (about 10 nm). Besides, while taste is related to the total surface of the salt grains, the body salt intake is not related to its surface, but to the whole volume/mass that enters the body. Therefore, by decreasing grain size we maximize surface area while minimizing mass, so keeping the taste and decreasing the body intake, which makes food tasty and healthier at the same

time. The other technical interest is in food preservation, thanks to nanostructured barriers or biocide nanoparticles, for example. To have the ability to preserve food in its full power while avoiding expensive cool treatment and storage, or pasteurization, is important. Adding mineral micronutrients with nanoparticles, as Fe, Zn, Se or others, may also be something to explore that would allow us to prepare more sophisticated and healthier recipes. Those minerals are present in nature, also in sub-micrometric and -nanometric forms at the biological interface, and it has been known for decades that lands rich in those minerals tend to produce crops rich in them.





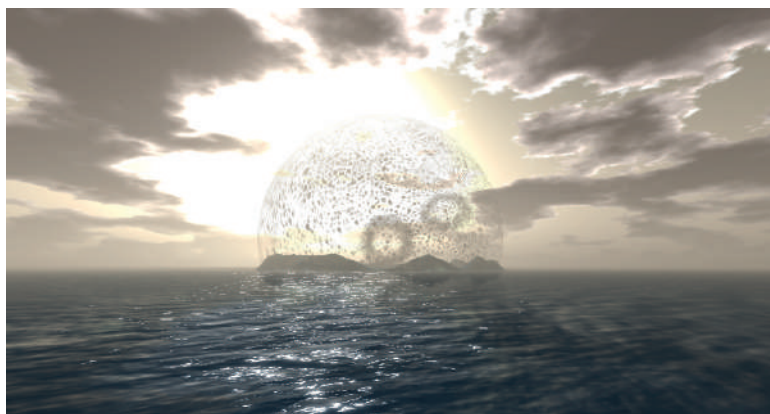
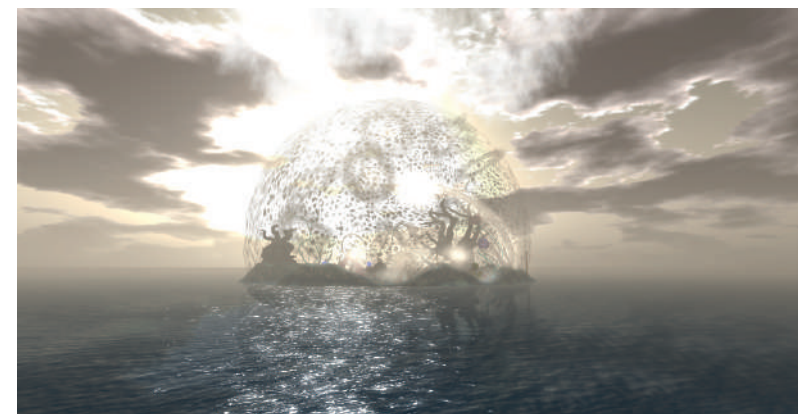
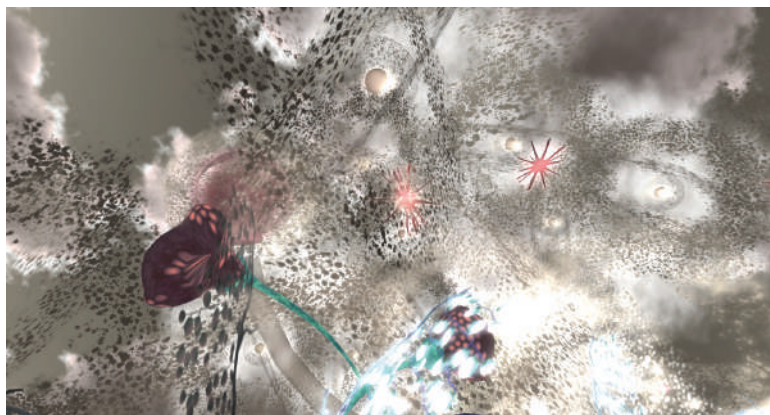


*Looking around us we realize
that nanotechnology is not an invention,
it is a marvellous discovery.*

*Therefore, and we must be very clear here,
at this stage of technological complexity and species challenges,
it is not so much the what for, but the what do I learn from it,
in addition to maintaining a sustained healthy attitude
of wonder and exploration.*

*One day,
science will free us from (today's) technology.*

*Víctor Puentes and the Inorganic Nanoparticles Group
January 2013*



*The images that accompaing this text are extracted
from a recreation of a virtual walk-in world (second life)
where the textures are made of electron micrographs on inorganic
nanoparticle assemblies, such as those of gold, cobalt or iron oxides.*

*A world inspired in images cuts
from transmission electron microscopy
on spontaneously assembled nanoparticles reactions.*

A world where forms create forms.

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 > see this capsule in page 60
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[http://nanowiki.info/#\[\[Nanoparticles in caramels, sugar, bread...\]\]](http://nanowiki.info/#[[Nanoparticles in caramels, sugar, bread...]])

nanowiki.info

>>> tracking nanotechnology

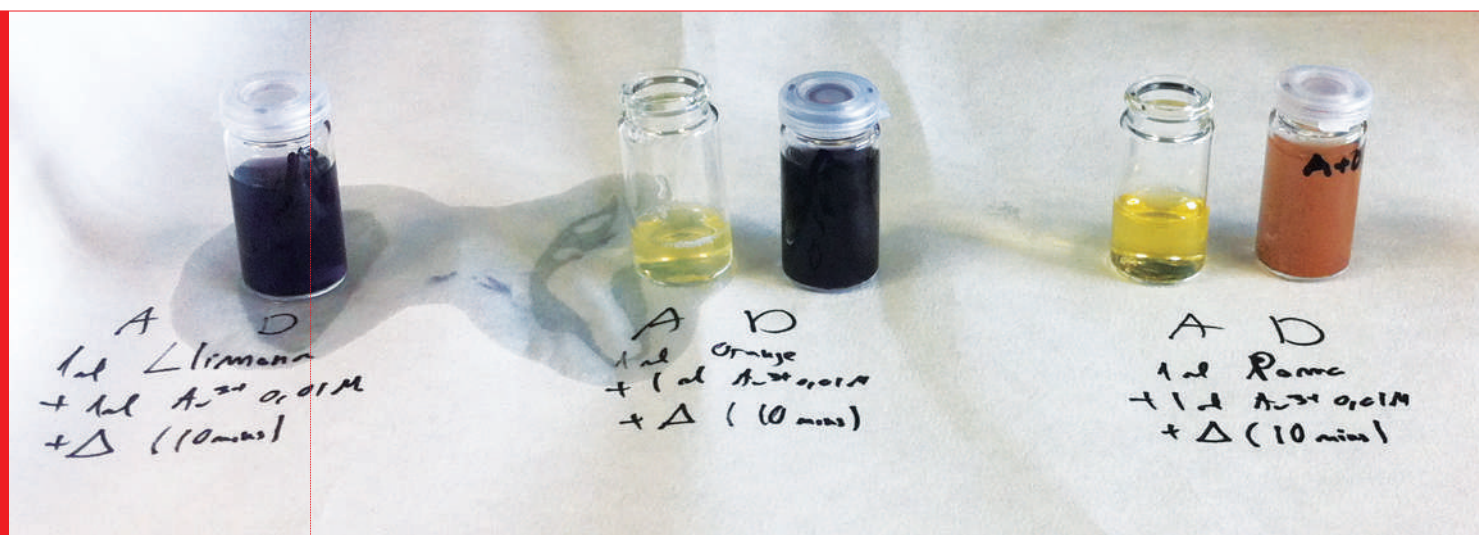


Hands On NanoWiki

Hands-on refers to human interaction, often with technology. It implies active participation in a direct and practical way.

- 34 **Hands On #1**
Synthesis of gold nanoparticles.
Use of nanoparticles for the early detection of diseases.
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Synthesis of cerium oxide nanoparticles.
Tyndall Effect.
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Synthesis of an aqueous ferrofluid.
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Manufacturing a solar cell with raspberry jam (or blueberry, or cherry, or ...) and buns (or donuts, or ...).
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Photonic crystals formation.
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- 46 **Hands On #7**
Nanoparticles: different composition, the same or different colors

Hands On #1



CONCEPT

A colloidal solution of gold nanoparticles changes its color depending on the size, shape and surface of their components. This simple experience illustrates how nanoparticles are used, among others, as a tool for medical diagnosis.

MATERIAL

- Hotplate with magnetic stirrer.
- Erlenmeyer flask.
- Reagents (metal precursors and surfactant molecules) for the synthesis of size-controlled gold nanoparticles.

EXPERIMENTAL PROCEDURE

1) Synthesis of nanoparticles.

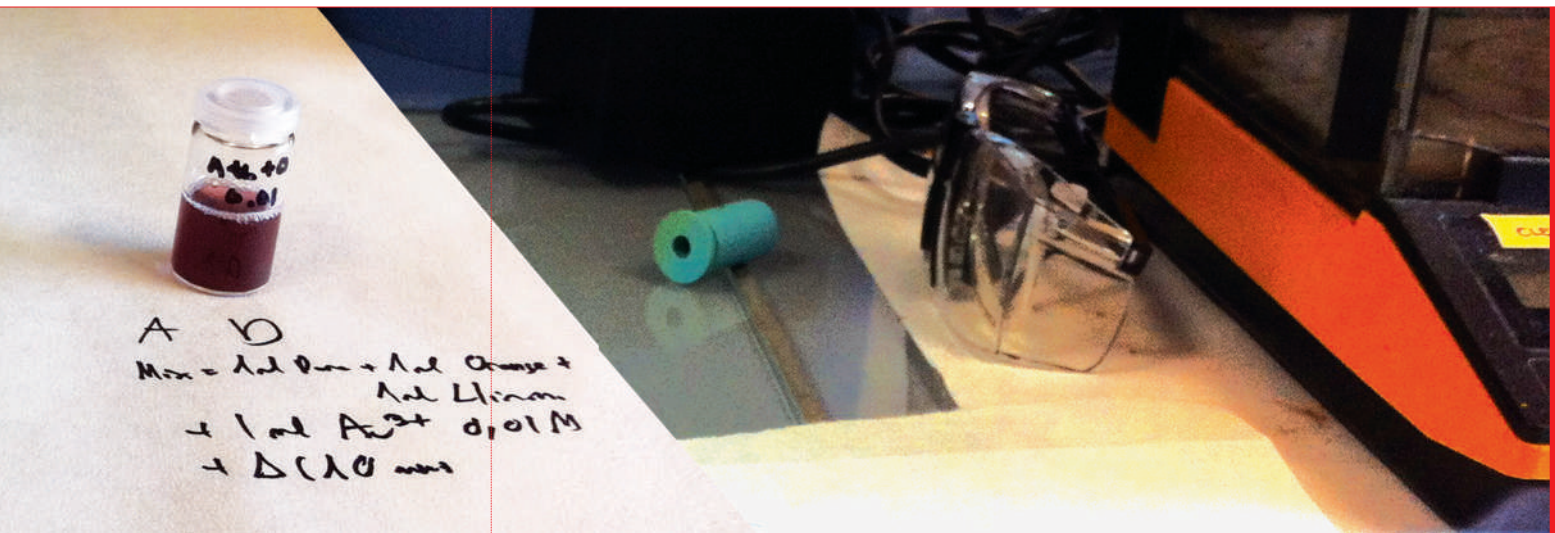
This procedure aims the production of gold nanoparticles of different sizes. Bring water to boil, and add pineapple juice (yellow) and a gold salt (yellow too). The solution will change its color from yellow to red in about 3 minutes, indicating the formation of gold nanoparticles. This experience may be accompanied by an explanation on how to handle chemicals reagents and how to prepare aqueous solutions in the laboratory. Total time is approximately five minutes once the water is brought to its boiling point.

2) Changes of color.

When common salt is added, the solution becomes first violet, and finally restores its original pineapple juice color, indicating the agglomeration and precipitation of gold nanoparticles.

Synthesis of gold nanoparticles.

Use of nanoparticles for the early detection of diseases.



CONCEPTUAL FRAMEWORK

Nanoparticles are very small solids, imperceptible to the human eye. However, dispersed in a liquid, the resultant colloidal suspension has a characteristic color which is given by the morphology of the gold nanoparticles. Alterations in size, shape and surrounding environment lead to variations in the sample color. This feature allows the use of nanoparticles as tools for the medical diagnosis. Thus, nanoparticles assist the detection of the so-called markers, molecules which signal the early stage of a disease, even when present in very low amounts. The colloidal solutions of nanoparticles previously linked to these markers present slightly variation of its color (in comparison to those non-linked). This linkage can be even extended to series of links between nanoparticle-nanoparticle-marker which induce the agglomeration and precipitation of nanoparticles causing a sharp change in color that can be seen by naked eye. This principle allows us to develop highly sensitive sensors based on nanoparticles which are able to detect a wide variety of diseases at their very early stage, being possible hence to treat them on time.

Gold nanoparticle synthesis will be carried out by using a common substance, the pineapple juice. This juice has sugars and other reducers, which are able to reduce Au^{3+} (ionic gold) to Au^0 (metallic gold). This metallic gold is organized to form nanoparticles which are stabilized by chains of sugars presents in the juice. By adding salts, the stability of the colloidal solution is lost and gold nanoparticles agglomerate changing their color to violet. Later, when these agglomerates reach a large size, they precipitate, restoring again the visible yellow color of the pineapple juice.

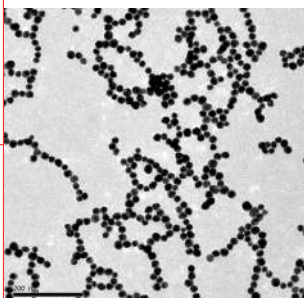
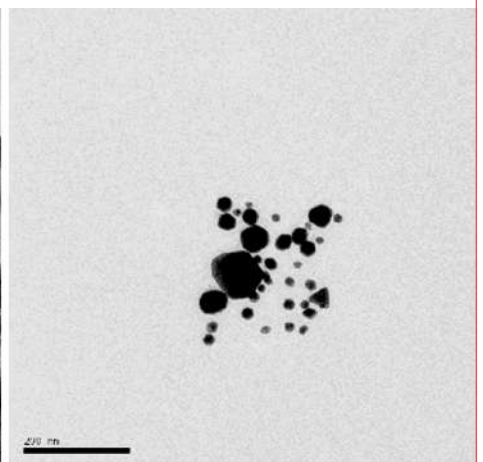
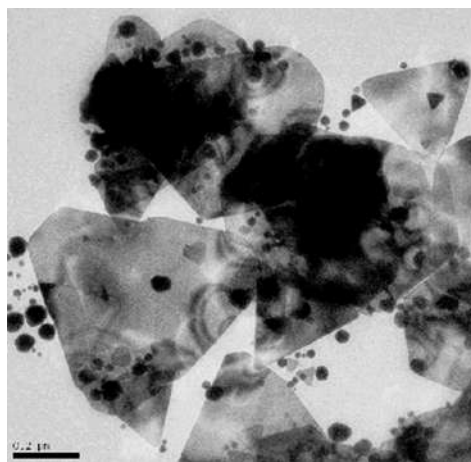


Image of TEM (Transmission Electron Microscopy) of gold nanoparticles synthesized in the laboratory, with greater control of the synthesis conditions.

Images of TEM (Transmission Electron Microscopy) of the gold nanoparticles obtained in this workshop.



Hands On #2



CONCEPT

The Tyndall effect is a natural phenomenon which provides a visible experience of the presence of colloidal particles, although they are not big enough to be seen by naked eye.

MATERIAL

- Chemical reagents needed for the synthesis of cerium oxide nanoparticles.
- Glass bottle or vial, magnetic stirrer plate and magnetic bar. The material is similar to those used in workshop 1 but in this case heating is not needed.
- Laser. Laser power has to be determined and adjusted according to the volume of the container where the nanoparticles are formed (it is a quick test).

EXPERIMENTAL PROCEDURE

The synthesis will be carried out in a transparent container (glass bottle or vial) by mixing a precursor (cerium-containing molecule) and an oxidizer (which will precipitate the cerium molecules), resulting in the formation of cerium oxide nanoparticles. Experimental conditions will be adjusted in order to ensure that the synthesis would take place within few minutes (less than 15). The formation of the particles will be followed by directing the laser through the container. Thus, it will be possible to follow the full trajectory of the laser (entering and exiting the container) only after the formation of the particles.

Synthesis of cerium oxide nanoparticles.

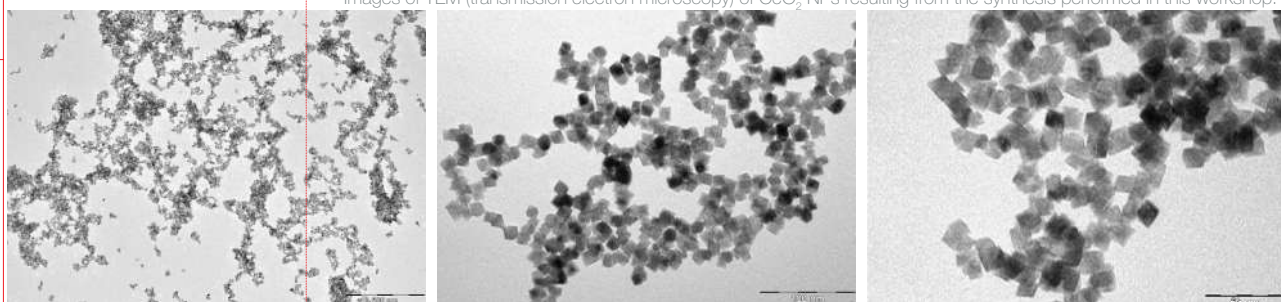
Tyndall Effect.



CONCEPTUAL FRAMEWORK

Differently from the pure solutions composed only by molecules, tiny solids that form a colloidal suspension of nanoparticles are able to scatter the light in such a way that it is possible to track a laser beam through the container, similarly to a ray of sunlight through the clouds. This phenomenon, known as Tyndall effect, allows distinguishing homogeneous mixtures composed by colloidal suspensions from those that only contain molecules. This effect can be also observed when car headlights pass through a fog cloud, when sunlight illuminates a dusty room or when it crosses the clouds containing water droplets.

Images of TEM (transmission electron microscopy) of CeO_2 NPs resulting from the synthesis performed in this workshop.



Hands On #3



CONCEPT

Nanotechnology as a tool for environmental remediation.

MATERIAL

- Reagents for the synthesis of iron oxide nanoparticles. Chemical agents (eg, a salt with copper ions) to be used as model contaminant.
- Glass bottle or vial where the synthesis of nanoparticles and the elimination of pollutants will be carried out, magnetic stirrer plate and magnetic bar.
- Magnet to further trap iron oxide nanoparticles.

EXPERIMENTAL PROCEDURE

Synthesis of magnetic iron oxide nanoparticles will be carried out in a glass bottle by mixing iron chloride salts in a basic medium. The synthesis takes place within 5-10 minutes after mixing all components. Meanwhile, in another flask, an aqueous solution of copper cations will be prepared, which will give a blue color to the solution. When finishing the synthesis, both solutions (nanoparticles and copper cations) will be mixed and stirred the time required for the absorption of copper cations (the “contaminant”) by iron oxide nanoparticles. Last step will be the separation of iron oxide nanoparticles by using a magnet, obtaining as a result a transparent solution of “clean” water.

[image next page]

Removing contaminants with Fe_3O_4 nanoparticles.

A) Top: water “contaminated” with copper cations. Bottom: iron oxide nanoparticles.

B) Both solutions are mixed and nanoparticles absorb contaminants.

C) Nanoparticles, having absorbed the contaminant, are recovered by using a magnet.

D) By separating nanoparticles, the water remains the transparent “clean” color.

Synthesis of an aqueous ferrofluid. Removing contaminants with iron oxide nanoparticles.



CONCEPTUAL FRAMEWORK

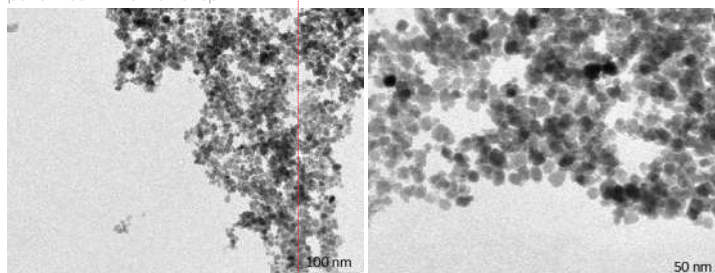
One of most important areas where nanotechnology has been proved effective is environmental remediation, in particular the cleaning and purification of waters by using inorganic nanoparticles. The ability of the inorganic particles to absorb contaminants was already known for cations such as arsenic (As), chromium (Cr), nickel (Ni) and Cadmium (Cd), among others. Nanoparticles have special and unique properties that can be used to degrade and efficiently trap contaminants, such as heavy metals dispersed in water. These properties include: i) a high surface-to volume ratio, i.e., for the same mass of material, the surface area of nanoparticles is extremely high in comparison to bulk materials, ii) a high mobility in solution, therefore nanoparticles can explore much more faster a given volume than larger particles. Furthermore, the trapped contaminants on the surface of nanoparticles can be further recovered by applying gravity gradients or magnetic fields. In such a way, nanoparticles can be easily and inexpensively recovered by centrifugation or magnets.

CONTEXT

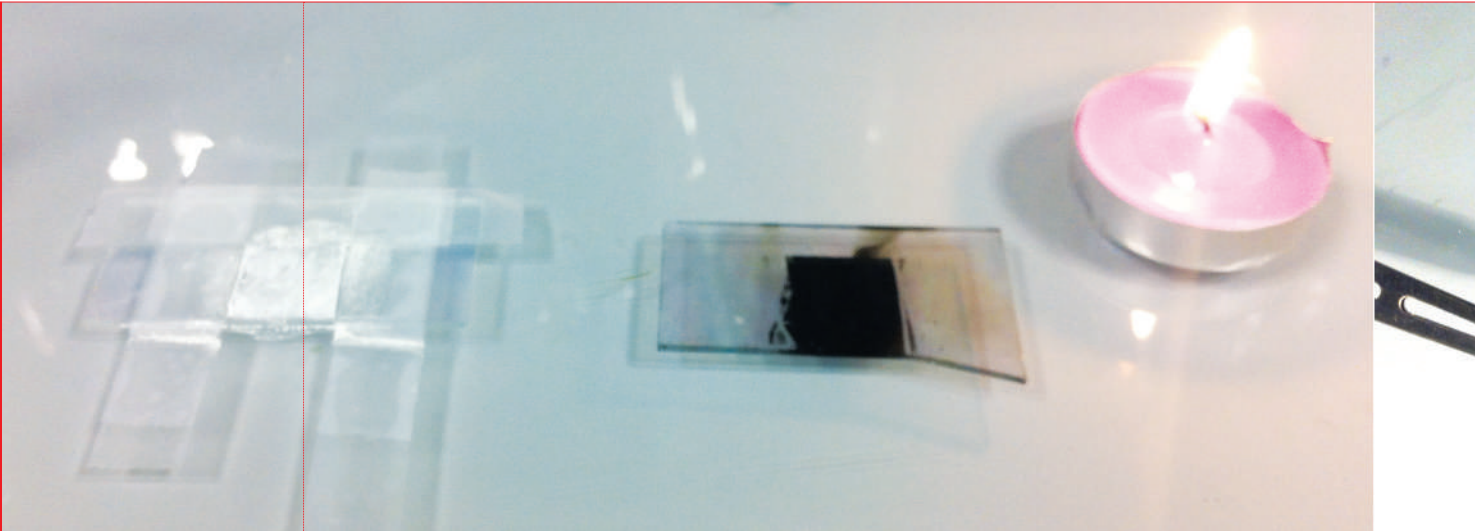
"In Bangladesh, before the year 1970, people had no contact with this pollutant, since they drank water coming from the surface, rivers and ponds. At that time, thousands of children die each year from diarrhea - 250000 according to the World Bank-, due to microorganisms present in the water. To avoid this problem the Government of Bangladesh and UNICEF launched a program to get people used to drink from wells that were started to be drilled all around the country. They did not know they were giving "Arsenico por compasión" (Spanish translation of Arsenic and Old Lace), title of the classic film starring Cary Grant. Thus, water from these wells were not checked for carcinogens levels. Water consumption profiles started to change quickly, and 95% of the population of Bangladesh began to use this new system. Other international cooperation organizations continued drilling wells and people also began to build their own ones. Finally, at the early nineties, the massive poisoning was discovered, after the population had been drinking contaminated water over many years."

Translated from "Agua que mata".
El País, 2 de Agosto 2009.

Images of TEM (transmission electron microscopy) of Fe_3O_4 NPs resulting from the synthesis performed in this workshop.



Hands On #4



CONCEPT

From materials present in our daily lives it is possible to implement a seemingly complex technology, as well as promising technology in the field of renewable energies. One example is to manufacture a photovoltaic (solar) cell which generates electricity from the sunlight.

MATERIAL

- Raspberry jam.
- Ensaimada with icing sugar (for industrial confectionery, containing E-171).
- Glass plate heat conductor (eg, 5x5 cm glass plates tin oxide coated).
- Oven or hot plate or flame (bunsen burner, candle,...).
- Clamps to hold the glass plate.
- Tester (multimeter) to measure electrical current.
- Clips.
- Potassium Iodide, Potassium Hydroxide or similar electrolytes.

EXPERIMENTAL PROCEDURE

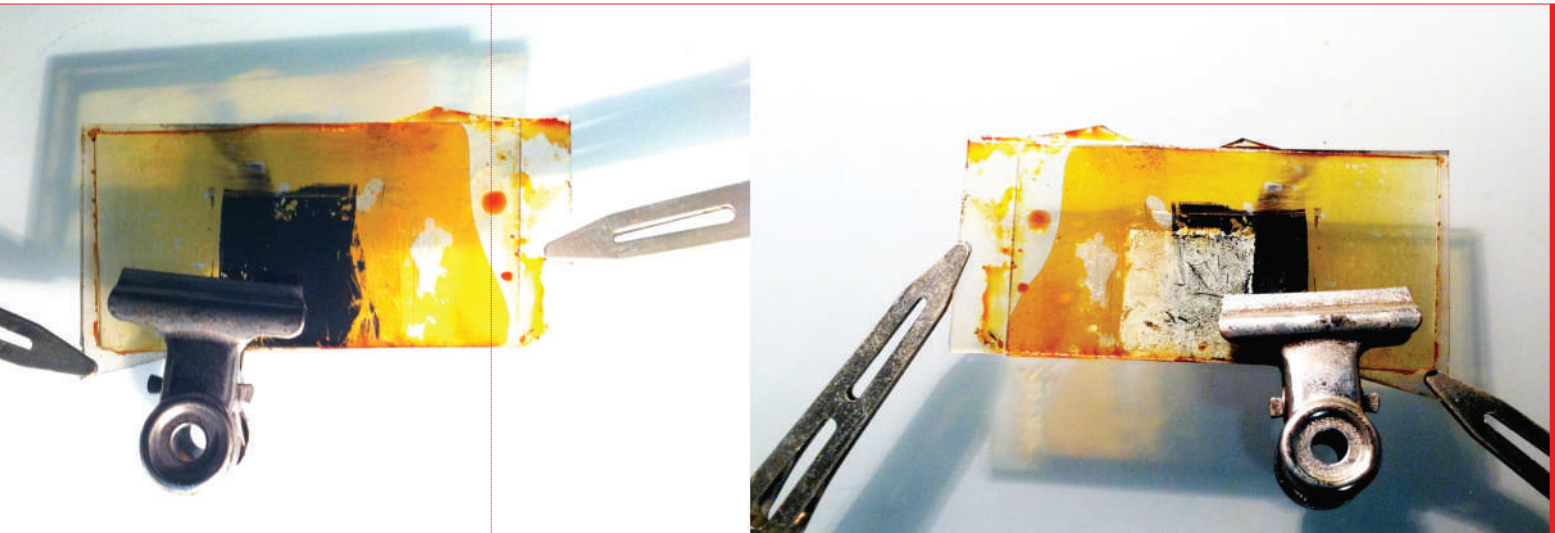
A) Titanium dioxide nanoparticles in powder form are in the icing sugar confectionery (specifically are the E-171 additive). Once separated, the powder is purified and deposited on the glass plate and heated to sintering the powder. Then the plate is immersed in the jam, and the titanium oxide changes its color since absorb anthocyanins present in the fruit. Excess of organic matter from the jam is washed.

B) Other glass is painted, for example with a pencil, to create a carbon (graphite) layer. Alternatively, this also can be created heating the glass with a bunsen burner or a candle.

C) Both glasses must be pieced together by their respective coatings (titanium oxide with the anthocyanins and the carbon) and tightened using the clips. Then, this set must be immersed in an electrolyte solution, which by capillarity permeate the space between the two glass plates.

D) Finally, the tester is connected with a clip at each glass plate, and the current produced in the presence and absence of sunlight or other source of white light is measured.

Manufacturing a solar cell with raspberry jam (or blueberry, or cherry, or ...) and buns (or donuts, or ...).



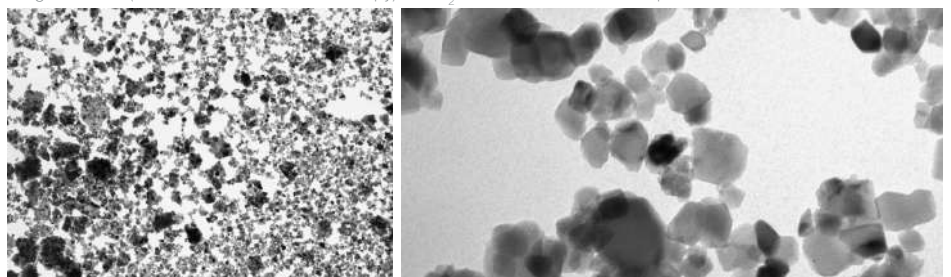
CONCEPTUAL FRAMEWORK

Photovoltaic cells, also called solar cells, are devices that generate electricity from light. The most common are made of silicon, like computer chips, but require an expensive process for its manufacture. An alternative to silicon solar cells are the dye-sensitized solar cells, less efficient but much less expensive. These are recognized as the third generation of photovoltaic technology. The inventor of this important development, Michael Graetzel, was awarded in 2010 with the Millenium Prize.

These type of cells promise windows and solar panels that generate electricity at a very low cost, and have recently been incorporated into consumer products. Thus, “Grätzel cells”, as they are also known, are expected to play an important role in large-scale and low cost solutions for renewable energies. Moreover, beyond photovoltaics, the scientific and technological concepts behind Grätzel cells can also be applied to batteries and hydrogen production.

This technology, often described as “artificial photosynthesis” is a promising alternative to silicon photovoltaics. Is made from low cost materials and does not require an elaborate manufacturing process. Is based on a semiconductor formed by a photo-sensitive anode and an electrolyte, i.e., a photoelectrochemical system. In these cells, the dye absorbs light and transfers the electrons excited to the titanium dioxide. This semiconductor material split the charge. Adding Potassio Iodide (KI) as electrolyte, the redox couple I^-/I_3^- complete the circuit. The titanium dioxide can come from the pastry icing sugar (the additive E-171) and the dye can come from the anthocyanins, pigments found in some vegetal cells, hence that raspberry jam, blueberries, blackberries or any other containing the blue pigment can be used.

Images of TEM (transmission electron microscopy) of TiO_2 NPs used in this workshop.



Hands On #5



CONCEPT

Photonic crystals consist on dielectric (insulators) or metallo-dielectric materials, which due to its periodic structure can modify the propagation of electromagnetic waves, such as the light. By forming a photonic crystal from latex beads, it could be seen the natural phenomenon behind the variety of colors of certain natural structures, such as butterfly wings, pearls, hummingbirds feathers, etc.

MATERIAL

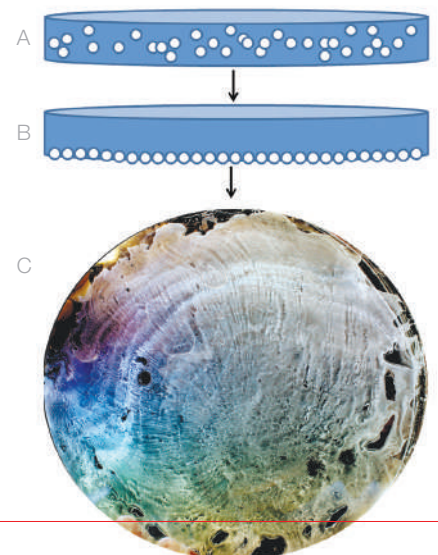
- Latex beads solution, polystyrene beads solution or similar (size range 500 to 1000 nanometers).
- Petri dish.
- Lamp or other heat source to accelerate evaporación.

EXPERIMENTAL PROCEDURE

Simply, latex or polystyrene beads are left to sediment (the sedimentation can be accelerated with a centrifute if needed). Afterwards, it is possible to observe the change of the color of the beads sedimented on the glass plate looking at it with different types of light and/or from different angles.

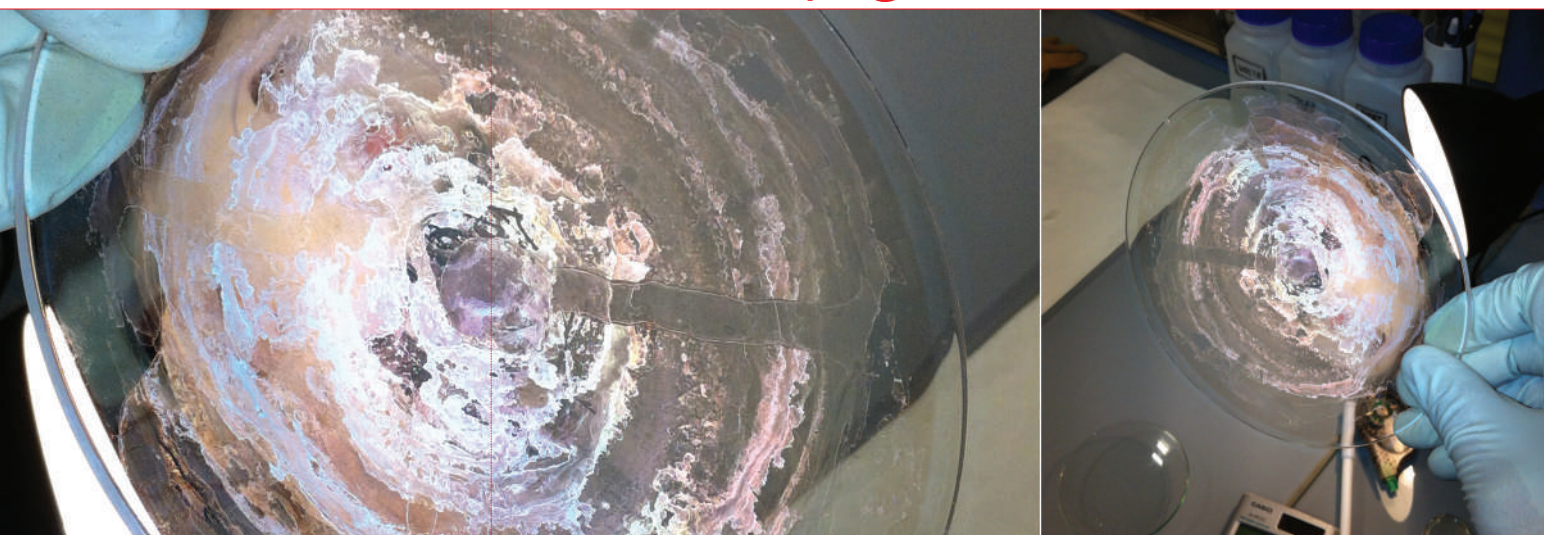
Scheme of the experimental procedure:

- A) Latex or polystyrene beads are in aqueous solution.
 B) Over time, they settle down and arranged on the base of the glass plate with a few nanometers separation between each sphere.
 C) Looking at the plate with different types of light and/or from different angles it can be seen how the color is modified.



Photonic crystals formation.

Natural strategies to create color in the absence of pigments.



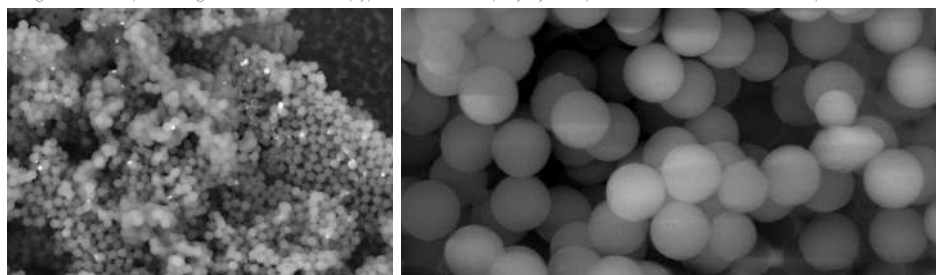
CONCEPTUAL FRAMEWORK

Oil stains or soap bubbles, to name few examples, seem to change color depending on the angle from which we look at them. This phenomenon is known as iridescence, from the Greek word “iris” which means light. This phenomenon is caused by multiple changes of direction (reflection) of the light due to nanometric rugosities of the material. This is a strategy of nature to create color in the absence of pigments or other specific molecules, and it is present in the pearls, butterfly wings or hummingbirds and peacocks feathers.

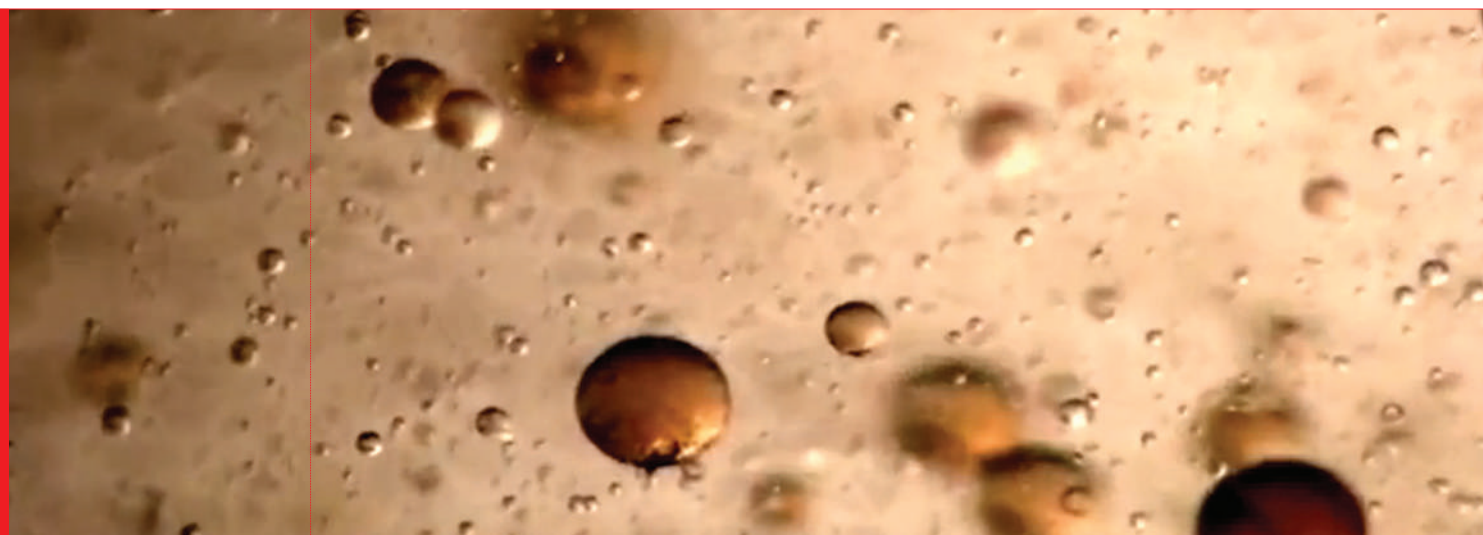
In the glass plates are deposited millions of monodisperse tiny spheres of polystyrene of 200-1500 nanometers in diameter, with a few nanometers of separation between each sphere. It can be seen how colors vary depending on the angle from which the surface is observed.



Images of SEM (scanning electron microscopy) of commercial polystyrene particles used in this workshop.



Hands On #6



CONCEPT

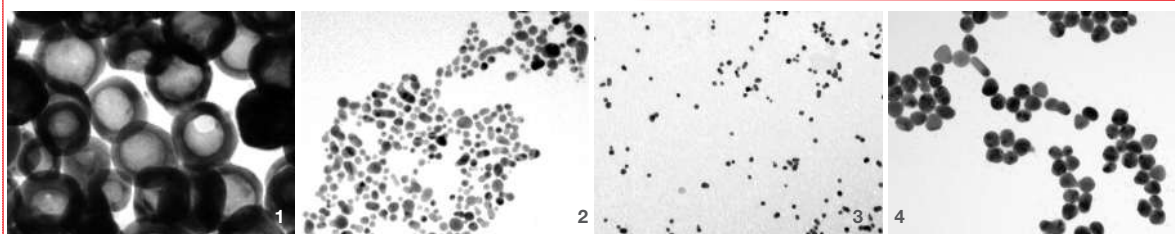
Demonstrative Workshop: The richness and variety of technological, scientific and aesthetic possibilities that offers inorganic matter at the nanoscale.

MATERIAL

- Bottles filled with dichroic colloids that observed in transmission/reflection are green/orange.
- Ferrofluids: Concentrating iron oxide nanoparticles and approaching/moving the magnet results in more showy shapes.
- Bottles filled with unstable colloids that quickly and differently sediment.

EXPERIMENTAL PROCEDURE

Taking advantage of these demonstrations, it will be explained, for instance, the mechanisms that lead nanoparticles of the same composition to present different color in transmission and reflection; which is the importance of ferrofluids; the forces that play a role in the nanoparticle stability (Brownian motion versus gravity).



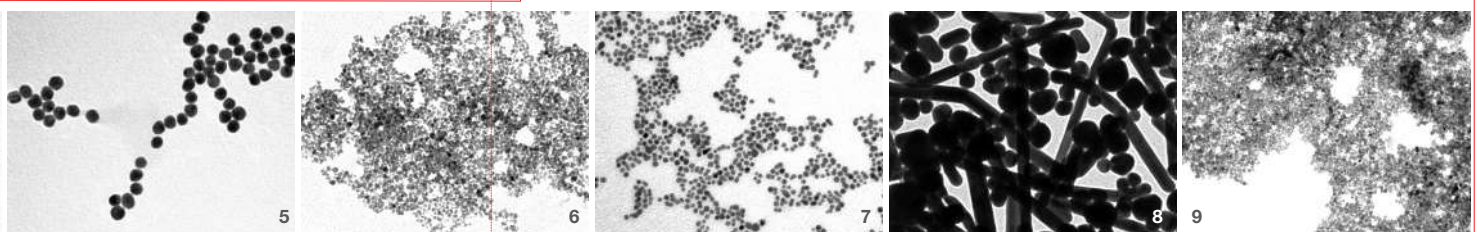
The richness of the nanometric world.



CONCEPTUAL FRAMEWORK

At the nanoscale, materials properties that we know are determined. These properties, color, hardness, reactivity, thermal conductivity, magnetism, etc., are not properties of the atoms, but of the materials they form. For instance, from carbon, materials as diverse as pencil leads, diamonds and coal can be formed. It is when atoms organize when material properties are determined, and it is in the scale of few nanometers, where the number of atoms is still modest, that these properties emerge and are modular. This is known in the world of molecules where particular organizations of atoms results in different compounds, such as the toxic CO and the innocuous CO₂. There is a biological analogy in nanotechnology almost always. Quintessential biological nanoparticles are proteins. Despite being all of them formed by the same 20 amino acids, made from the same chemical components (C, H, O, N, S), they can be as different as simply food or neurotransmitters of happiness. Nanotechnology development opens our knowledge of the molecular world, traditionally of organic and biological molecules, to the inorganic world. A set of units of modular properties, relatively stable and controllable, should enable both a better understanding of the world that is around us and a more efficient technological development.

- 1) Hollow gold nanoparticles (empty) (AuNPs) of size 50 nm
- 2) Nanoparticles (AgNPs) size 10-20 nm, stabilized with sodium citrate
- 3) Gold nanoparticles (AuNPs) size 3-4 nm, stabilized with CTAB (a detergent)
- 4) Nanoparticles (AgNPs) of size 30 nm, stabilized with sodium citrate
- 5) Gold nanoparticles (AuNPs) of size 15 nm, stabilized with sodium citrate
- 6) Magnetite nanoparticles iron oxide (Fe₃O₄NPs) size 7-8 nm, stabilized with an ammonium salt
- 7) Gold nanoparticles (AuNPs) size 3-4 nm, stabilized with sodium citrate
- 8) A mixture of nanoparticles (AuNPs) and Gold (AuNRs) Nanorods (cylinders) stabilized with CTAB (a detergent)
- 9) Magnetite nanoparticles of iron oxide (Fe₃O₄NPs) size 7-8 nm, stabilized with an ammonium salt



Hands On #7



CONCEPT

Nanoparticles are solid materials smaller than the length of wavelengths corresponding to the visible light (400-700 nm), enabling materials with interesting optical behaviour.

MATERIAL

- Bottles with different types of colloidal nanoparticles, each of a different color depending on their morphological properties. For example, blue, red and green gold nanoparticles and yellow, orange and green silver nanoparticles, etc.

EXPERIMENTAL PROCEDURE

It could consist on a game like “guess composition according to the color”: looking at the color of the colloid should guess the composition of nanoparticles inside the bottle.

Nanoparticles: different composition, the same or different colors.



CONCEPTUAL FRAMEWORK

Nanoparticles are tiny solids, imperceptible to the human eye. Noble metal nanoparticles suspended in a liquid disperse light without reflecting it, creating a perception of the color that varies depending on their size, shape and surroundings. For example, at the nanoscale, gold surprises us with reflections ranging from red to blue, creating a palette of colors with only one material.

“The color corresponds to a physiological perception interpreted in the brain based on the wavelength of the light that affects the eye. The human eye is trained to respond to wavelengths in the range 380-750 nm, belonging to the visible spectrum. Although it is not possible to rigorously consider a color completely pure, each color is associated to a range of wavelengths: red, for the interval 650-750 nm; green for the interval 500-560 nm; blue for the interval 435-480 nm, and so on. In the simplest case, bodies bathed with white light absorb part of the spectrum and reflect other. Reflected light is captured by the eye and interpreted in the brain as color. Basically, the processes responsible for enabling colors are complex and varied. Fifteen different mechanisms explaining processes that occur when light interacts with matter to produce color have been identified, which include: i) Vibrations and simple excitations in hot objects. ii) Transitions between molecular orbitals, responsible for the color in organic compounds such as dyes, biological colouring, laser. iii) Effects of energy band that produce color in metals, alloys and semiconductors. iv) Diffraction, refraction, scattering, polarization, dispersion, interference without diffraction, etc.

Considering the case of color in particular metal bodies, wherein the color depends on two factors: the type of material on the surface of the body and the light that illuminates it. When light comes into contact with macroscopic metallic bodies, it is strongly absorbed by the outer layers of atoms forming the metal surface, and then it is re-emitted with an efficiency which depends on the wavelength of incident light. If the re-emission process is the same for all wavelengths in the visible spectrum, silvery colors are produced like those seen in the iron, chromium or silver. In the case of gold, the efficiency decreases with the wavelength, which results in a preferential re-emission of yellow and red colors, which give the characteristic gold color. In the case of alloys, among other considerations, the color depends on the proportion of the metals involved. In the case of gold-silver alloys in a 4:1 ratio, green colors are observed. In the case of gold-copper in the same proportion, reddish colors are observed. In the case of a gold film thin enough for light to pass through it (few tens of nm), a reddish-yellow color is observed for reflected light while blue-green color is observed holding the film against the light, corresponding to the wavelengths that are not reflected.” (Dr. Edgar Gonzalez)

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News NanoWiki

Selected news from nanowiki.info
under the tag **nano before nanotech**

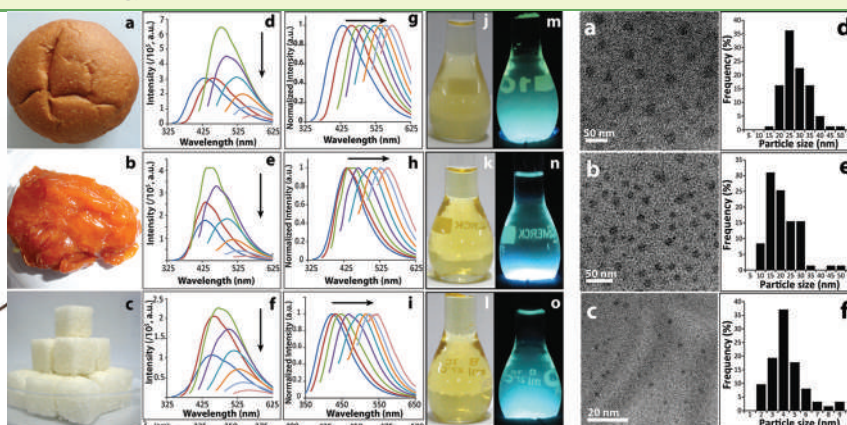
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Nanoparticles in caramels, sugar, bread...

josep saldaña, May 14, 2012

tags: nano before nanotech + nanoparticles + nanotoxicology + food



(a), (b), (c) Photographs of commercial bread, jaggery and sugar. (d)–(i) excitation wavelength dependent emission spectra of CNPs from bread, jaggery and sugar caramel. (j)–(l) photographs of dispersions of CNPs from bread, jaggery and sugar caramel observed under white light and (m)–(o) the same under UV light.

(a), (b), (c) TEM images of CNPs extracted from bread, jaggery and sugar caramel and (d), (e), (f) corresponding particle size distributions of samples in that order.

Researchers from India investigate for the presence of carbon nanoparticles in different carbohydrate based food caramels, viz. bread, jaggery, sugar caramel, corn flakes and biscuits, where the preparation involves heating of the starting material.

"We report the finding of the presence of carbon nanoparticles in different carbohydrate based food caramels, viz. bread, jaggery, sugar caramel, corn flakes and biscuits, where the preparation involves heating of the starting material.

"The carbon nanoparticles were amorphous in nature; the particles were spherical having sizes in the range of 4–30 nm, depending upon the source of extraction. The results also indicated that particles formed at higher temperature were smaller than those formed at lower temperature.

"Excitation tuneable photoluminescence was observed for all the samples with quantum yield 1.2, 0.55 and 0.63%, for carbon

nanoparticles from bread, jaggery and sugar caramels respectively.

The present discovery suggests potential usefulness of carbon nanoparticles for various biological applications, as the sources of extraction are regular food items, some of which have been consumed by humans for centuries, and thus they can be considered as safe.

Source: This work is detailed in the paper "**Presence of Amorphous Carbon Nanoparticles in Food Caramels**" by Md Palashuddin Sk, Amit Jaiswal, Anumita Paul,

Siddhartha Sankar Ghosh & Arun Chattopadhyay.

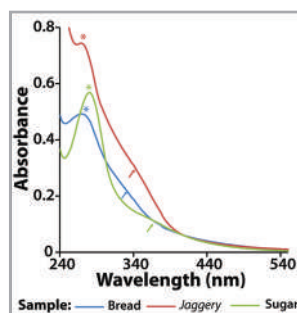
Context:

May 11, 2012. **Nanoparticles found in our daily food** by Renae Soppe, Cosmos online. "If we and our ancestors have been eating these nanoparticles for centuries (if not for millennia) and if these particles can offer some benefits of nanomaterials – then why not use them? (...) They have the potential to improve public perception on the safety of nanoparticles. This does not still mean that all nanoparticles are safe. Some are and some are not," Chattopadhyay said."

October, 2011. **Challenging conventional thinking on the reactivity of nanoparticles**

September, 2011. **Is Nanofood Approaching the Table?**. CNBSS

May 2011. **Debate: Nanotechnology and Food**

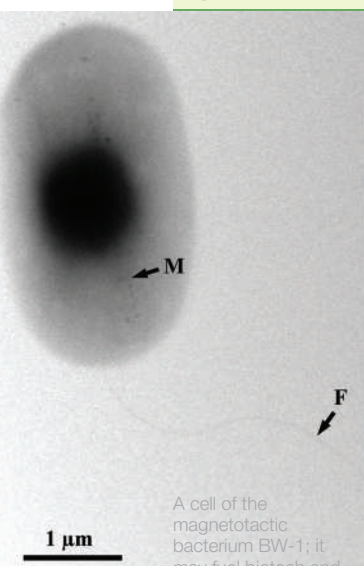


UV-vis spectra of CNPs extracted from bread, jaggery and sugar caramel.

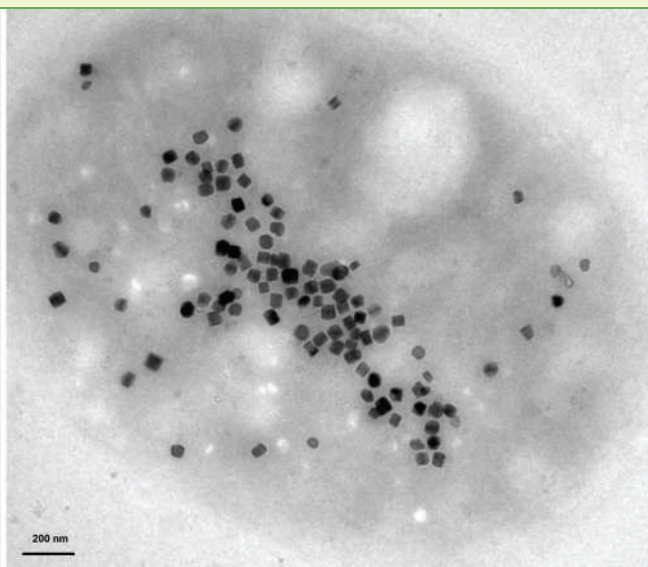
Death Valley microbe may spark novel nanotech uses

josep saldaña, January 2, 2012

tags: nanobiotechnology + nanomedicine + nano before nanotech



A cell of the magnetotactic bacterium BW-1; it may fuel biotech and nanotech discoveries. Credit: Dennis Bazylinski and Christopher Lefèvre



Greigite-containing magnetotactic bacterium from Badwater Basin, Death Valley. Credit: Dennis Bazylinski and Christopher Lefèvre.



Badwater Basin, lowest elevation in North America, and Spring at Badwater Basin at Death Valley. Credit: Dennis Bazylinski and Christopher Lefèvre

Researchers report that they **identified, isolated and grew a new type of magnetic bacteria** that could lead to novel biotech and nanotech uses.

Nevada, the “Silver State,” is well-known for mining precious metals. But scientists Dennis Bazylinski and colleagues at the University of Nevada Las Vegas do a different type of mining. They sluice through every water body they can find, looking for new forms of microbial magnetism. In a basin named Badwater on the edge of Death Valley National Park, Bazylinski and researcher Christopher Lefèvre, from the French National Center of Scientific Research, hit pay dirt.

Magnetotactic bacteria [see page 58] are simple, single-celled organisms that are found in almost all bodies of water. As their name suggests, they orient and navigate along magnetic fields like miniature swimming compass needles. This is due to the nano-sized crystals of the minerals magnetite or greigite they produce. The presence of these magnetic crystals makes the bacteria

and their internal crystals — called magnetosomes — useful in drug delivery and medical imaging.

“The finding is significant in showing that this bacterium has specific genes to synthesize magnetite and greigite, and that the proportion of these magnetosomes varies with the chemistry of the environment,” said Enriqueta Barrera, program director in NSF’s Division of Earth Sciences.

While many magnetite-producing bacteria can be grown and easily studied, Bazylinski and his team were the first to cultivate a greigite-producing species. Greigite is an iron sulfide mineral, the equivalent of the iron oxide magnetite. “Because greigite-producing bacteria have never been isolated, the crystals haven’t been tested for the types of biomedical and other applications that currently use magnetite,” said Bazylinski. “Greigite is an iron sulfide that may be superior to magnetite in some applications due to its slightly different physical and magnetic properties. Now we have the opportunity

to find out.”

Researchers found **the greigite-producing bacterium, called BW-1**, in water samples collected more than 280 feet below sea level in Badwater Basin. Lefèvre and Bazylinski later isolated and grew it leading to the discovery that BW-1 produces both greigite and magnetite. A detailed look at its DNA revealed that BW-1 has two sets of magnetosome genes, unlike other such bacteria, which produce only one mineral and have only one set of magnetosome genes. This suggests that the production of magnetite and greigite in BW-1 is likely controlled by separate sets of genes. That could be important in the mass production of either mineral for specific applications.

Source: Badwater Basin: Death Valley Microbe Thrives There. This work was detailed in the paper **A Cultured Greigite-Producing Magnetotactic Bacterium in a Novel Group of Sulfate-Reducing Bacteria** by Christopher T. Lefèvre, Nicolas Menguy, Fernanda Abreu, Ulysses Lins, Mihály Pósfai, Tanya Prozorov, David Pignol, Richard B. Frankel, Dennis A. Bazylinski.

Natural nanopolymers used as drug carriers

josep saldaña, December 28, 2011

tags: nanofiber + nanocrystals + food nanomedicine + drug delivery + nano before nanotech



Nano-cellulose drug carriers were produced by Iranian researchers from Islamic Azad University in association with their colleagues from Northern Carolina University of the US in a bid to fight various types of illness-causing bacteria such as bacteria that are resistant against antiseptics.

“Natural nanopolymers, among which nano-cellulose is one of the most important ones, attracted the attention of researchers about 10 years ago. Nano-cellulose consists of crystalline and biological particles and they can be used as the base material in many industries due to their ability of surface modification,” Dr. Hassan Sadeqifar, member of the Scientific Board of Islamic Azad University, told the news service of the INIC.

Studying at Northern Carolina State University in the United States at post-doctorate level in the field of natural nanomaterials, Sadeqifar has carried out research aiming at presenting a new method for the

production of cellulose nanoparticles from cellulose fibers and to carry out chemical modification on the surface of such particles in order to be used in antibacterial and medical purposes.

“Cellulose nanoparticles are chemically neutral but biologically degradable and compatible with human’s body.

Therefore, in addition to compatibility with human body’s tissues, such materials degrade gradually when they are used as the base material in the production of antiseptics or drug carriers,” Sadeqifar continued.

Cellulose nanoparticles have applications in numerous industries such as polymer, food, nano-electronics, paper fabrication, filters for chemical materials and gases neutralization, textile, and so forth. However, their application in medical purposes and drug carriers was the main purpose of this study.

Source: Iranian, American Researchers Produce Nano-Cellulose Drug Carriers. This work was detailed in the paper

Photobactericidal porphyrin-cellulose nanocrystals: synthesis, characterization, and antimicrobial properties by Feese, E., Sadeghifar, H., Gracz, H. S., Argyropoulos, D. S., & Ghiladi, R. A.

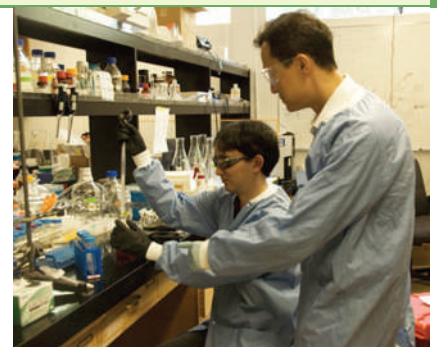
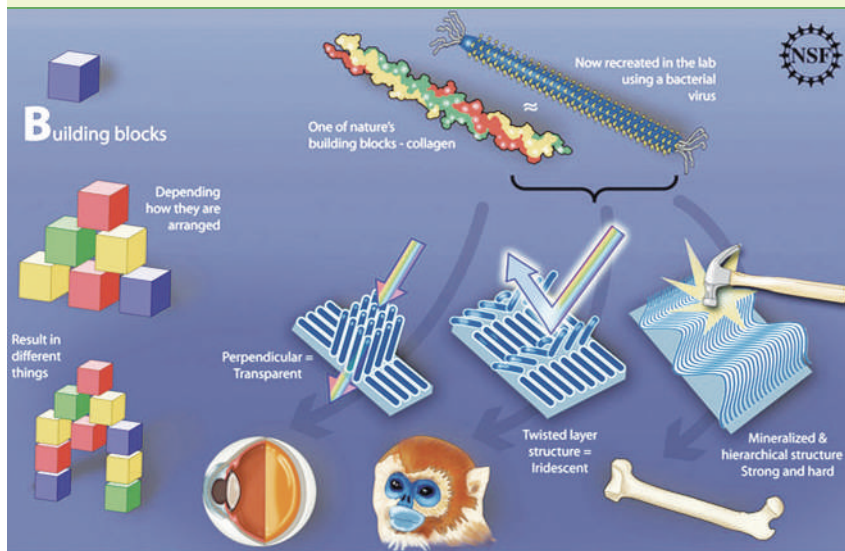
Context: Bridging the gap: Science help brings Iranian and UNC researchers together by Robert Tilford, Charlotte City Buzz Examiner.

“It’s not every day I run across an article in Iran which mentions North Carolina State University, or for that matter the United States in a positive light, but today I did. I guess I was surprised it didn’t have to do with CIA spies, secret drones, nuclear weapons or terrorism. God knows we hear enough of that kind already. Instead it had to do with a incredible medical break though that holds great promise in dealing with super resistant bacteria that can cause food borne illness (colloquially referred to as food poisoning).”

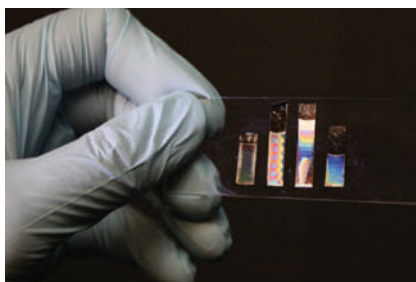
The virus is emerging as a nanoscale tool

josep saldaña, November 9, 2011

tags: nano before nanotech + nanomanufacturing + self-assembly

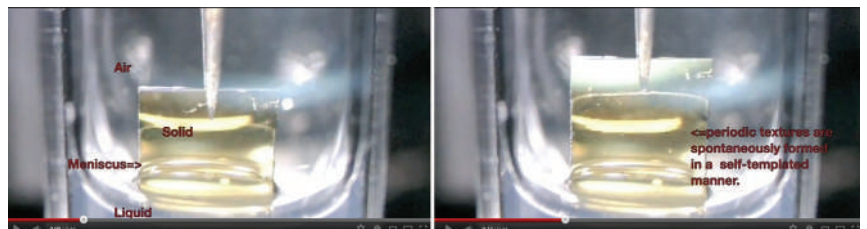


Woo-Jae Chung and Seung-Wuk Lee prepare solutions containing bacteria-eating M13 viruses. The researchers have developed a process that uses the viruses to assemble collagen-like materials. (Sarah Yang photo)



The materials created with the help of viruses could eventually be used to create complex biological tissues, such as cornea, skin and bones. (Woo-Jae Chung photo)

UC Berkeley researchers have turned viruses into molecular building blocks that mimic collagen. (Graphic by Zina Deretsky, National Science Foundation)



Frames from video "Self-Templating Materials Assembly"

Researchers have **turned a benign virus into an engineering tool for assembling structures that mimic collagen**, one of the most important structural proteins in nature. The process they developed could eventually be used to manufacture materials with tunable optical, biomedical and mechanical properties.

Source: Researchers turn viruses into molecular Legos by Sarah Yang

In a NSF webcast, University of California at Berkeley bioengineer Seung-Wuk Lee describes how his team developed **a new way to rapidly and efficiently manufacture novel nanomaterials using viruses as the building blocks.**

Video: Self-Templating Materials Assembly: "We developed novel materials assembly process to mimic complex biological structures with tunable optical, mechanical and biological functions. In this movie, we assembled the phage, bacteria-attaching viruses, (model system used for this study) into large area films by creating an apparatus to vertically pull substrates from a soup of viral solution at precisely controlled speeds."

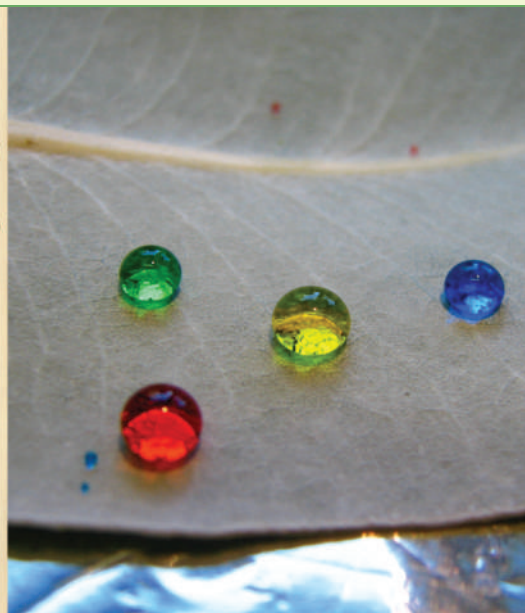
Eucalypt's nano properties

josep saldaña, November 1, 2011

tags: nano before nanotech + green chemistry + nanoremediation + water



E. macrocarpa, as figured by Walter Hood Fitch in 1847.



Coloured drops of dye on a mottled leaf

Nano scientists have discovered that **a eucalyptus plant native to south west Western Australia has unique self-cleaning and water-repellent properties which could make it a gold mine for new nanotechnology applications.**

The Mottlecah, which is also known as The Rose of the West for its large spectacular flowers, has silvery leaves which are covered in a wax which produces nano-sized bumps and pillars. This causes water to form droplets that roll over the surface of the leaves and fall towards the root system of the plant, picking up any dirt along the way.

These properties, which are known as superhydrophobic and self-cleaning, **are similar to the lotus plant's** which has inspired a range of self-cleaning and anti-bacterial technologies currently being developed.

Dr Gerrard Eddy Jai Poinern and his team at the Murdoch Applied Nanotechnology Research Group say their discovery has the potential to be applied in a variety of ways, from so-called lab-on-a-chip settings in medical research, to the treatment of ships' hulls to help prevent the build up of harmful

microorganisms, plants and animals. "I had noticed these incredible plants on the Murdoch campus because of the unusual appearance of their leaves," said Dr Poinern, who is based at the School of Engineering and Energy. "They made me wonder whether the plant had superhydrophobic properties and so began our research investigation.

"One of the experiments we carried out was to coat the leaf with carbon black toner from a laser printer cartridge and then observe how the rolling drops of water were able to completely clean the surface of the leaf.

"This was because the surface features formed by this Eucalyptus' waxes gave the leaves remarkable wetting and self-cleaning properties. We believe this enhances the plant's survival in an arid climate because it is able to source and effectively manage its water usage through channelling any water to its roots.

"In this way the Mottlecah is unusual because most superhydrophobic plants are usually found in aquatic settings."

Dr Poinern and his team also extracted waxes from the leaves and found that they

were capable of self-reassembly. When coated on laboratory glass slides, the wax formed features which mimicked the complex three-dimensional geometry of the nano-sized bumps and pillars found on the original leaf surface, making the slide superhydrophobic.

"It was fairly easy and inexpensive to extract the wax from the leaves and yet the wax still had these remarkable qualities," said Dr Poinern. "When the tested glass slides were placed horizontally onto a water surface, the added buoyancy support of the wax meant that it was able to carry a greater load than the uncoated slides.

"In microfluidic devices used in advanced medical research and disease testing, such coatings could help to maintain the sterility of devices which need to be used over and over again.

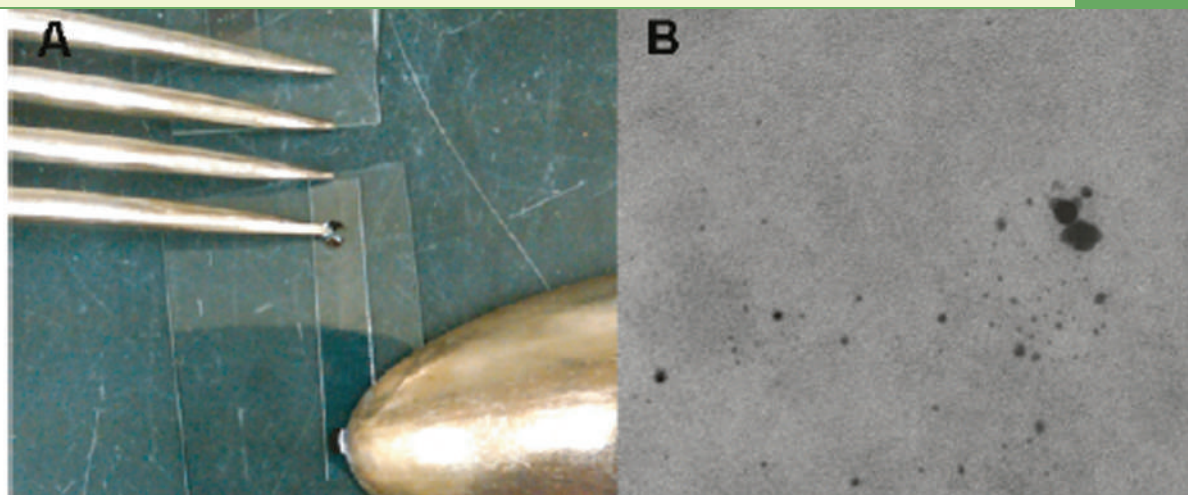
"In fact there are a number of potential applications and we are sure there are other WA native plants which have similar properties. We hope to continue our research to find out more about these properties and how they can be fully utilised."

Source: Researchers reveal Eucalypt's nano properties.

Challenging conventional thinking on the reactivity of nanoparticles

josep saldaña, October 25, 2011

tags: nano before nanotech + nanotoxicology + concerns + regulation + nanoparticles + nanosilver



Common flatware releases nanoparticles under certain conditions

If you've ever eaten from silverware or worn copper jewelry, you've been in a perfect storm in which nanoparticles were dropped into the environment, say scientists at the University of Oregon. Since the emergence of nanotechnology, researchers, regulators and the public have been concerned that the potential toxicity of nano-sized products might threaten human health by way of environmental exposure.

Now, with the help of high-powered transmission electron microscopes, chemists captured never-before-seen views of miniscule metal nanoparticles naturally being created by silver articles such as wire, jewelry and eating utensils in contact with other surfaces. It turns out, researchers say, nanoparticles have been in contact with humans for a long, long time.

The project involved researchers in the UO's Materials Science Institute and the Safer Nanomaterials and Nanomanufacturing Initiative (SNNI), in collaboration with UO technology spinoff Dune Sciences Inc. SNNI is an initiative of the Oregon Nanoscience and Microtechnologies Institute (ONAMI), a state signature research center.

The research focused on understanding the dynamic behavior of silver nanoparticles on surfaces when exposed

to a variety of environmental conditions.

Using a new approach developed at UO that allows for the **direct observation of microscopic changes in nanoparticles over time**, researchers found that silver nanoparticles deposited on the surface of their SMART Grids electron microscope slides began to transform in size, shape and particle populations within a few hours, especially when exposed to humid air, water and light. Similar dynamic behavior and new nanoparticle formation was observed when the study was extended to look at macro-sized silver objects such as wire or jewelry.

"Our findings show that nanoparticle 'size' may not be static, especially when particles are on surfaces. For this reason, we believe that environmental health and safety concerns should not be defined — or regulated — based upon size," said James E. Hutchison. "In addition, the generation of nanoparticles from objects that humans have contacted for millennia suggests that humans have been exposed to these nanoparticles throughout time. Rather than raise concern, I think this suggests that we would have already linked exposure to these materials to health hazards if there were any."

Any potential federal regulatory policies, the research team concluded, should allow for the presence of background levels of nanoparticles and their dynamic behavior in the environment.

Because copper behaved similarly, the researchers theorize that their findings represent a general phenomenon for metals readily oxidized and reduced under certain environmental conditions. "These findings," they wrote, "challenge conventional thinking about nanoparticle reactivity and imply that the production of new nanoparticles is an intrinsic property of the material that is now strongly size dependent."

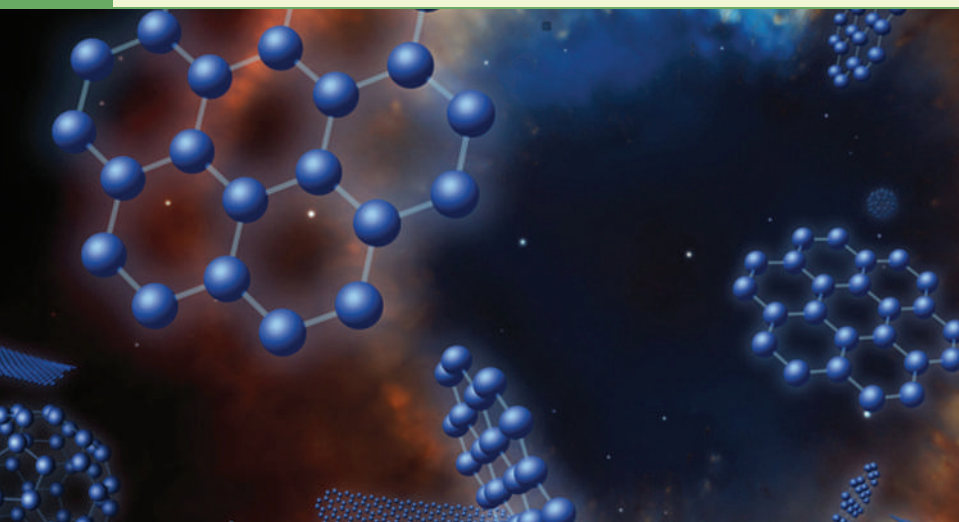
While not addressed directly, Hutchison said, the naturally occurring and spontaneous activity seen in the research suggests that exposure to toxic metal ions, for example, might not be reduced simply by using larger particles in the presence of living tissue or organisms.

Source: Nanoparticles and their size may not be big issues. This work was detailed in the paper **Generation of Metal Nanoparticles from Silver and Copper Objects: Nanoparticle Dynamics on Surfaces and Potential Sources of Nanoparticles in the Environment**

Has graphene been detected in space?

josep saldaña, August 23, 2011

tags: graphene + nano before nanotech + astronomy



Artist's impression of the graphenes (C24) and fullerenes found in a Planetary Nebula. The detection of graphenes and fullerenes around old stars as common as our Sun suggests that these molecules and other allotropic forms of carbon may be widespread in space. Credits: IAC; original image of the Helix Nebula (NASA, NOAO, ESA, the Hubble Helix Nebula Team, M. Meixner, STScI, & T.A. Rector, NRAO.)

A team of astronomers, using the Spitzer Space Telescope, have reported the first extragalactic detection of the C70 fullerene molecule, and the possible detection of planar C24 (“a piece of graphene”) in space. Letizia Stanghellini and Richard Shaw, members of the team at the National Optical Astronomy Observatory in Tucson, Arizona describe how collisional shocks powered by the winds from old stars in planetary nebulae could be responsible for the formation of fullerenes (C60 and C70) and graphene (planar C24). The team is led by Domingo Aníbal García-Hernández of the Instituto de Astrofísica de Canarias in Spain and includes international astronomers and biochemists.

Planetary nebulae originate from stars similar to our sun that have reached the end of their lives and are shedding shells of gas into space. In this case, the planetary nebulae are located in the Magellanic Clouds, two satellite galaxies to our own Milky Way, that are best seen from the Southern Hemisphere. At the distance of the Magellanic Clouds, planetary nebula appear as small fuzzy blobs. However, unlike planetaries in our own Milky Way Galaxy whose distances are very uncertain, the distance to

planetaries in the Magellanic Clouds can be determined to better than 5%. With such accurate distances, the research team determined the true luminosity of the stars and confirmed that the objects are indeed planetary nebulae and not some other object in the astrophysical zoo.

Fullerenes, or Buckyballs, are known from laboratory work on earth, and have many interesting and important properties. Fullerenes consist of carbon atoms arranged in a three dimensional sphere similar to the geodesic domes popularized by Buckminster Fuller. The C70 fullerene can be compared with a rugby ball, while C60 is compared to a soccer ball. Both of these molecules have been detected in the sample. Graphene (planar C24) is a flat sheet of carbon atoms, one atom thick, that has extraordinary strength, conductivity, elasticity and thinness. Cited as the thinnest substance known, graphene was first synthesized in the lab in 2004 by Geim and Novoselov for which they received the 2010 Nobel Prize in physics. “If confirmed with laboratory spectroscopy – something that is almost impossible with the present techniques – this would be the first detection of

graphene in space” said team member García-Hernández.

The team has proposed that fullerenes and graphene are formed from the shock-induced (i.e., grain-grain collisions) destruction of hydrogenated amorphous carbon grains (HACs). Such collisions are expected in the stellar winds emanating from planetary nebulae, and this team sees evidence for strong stellar winds in the ultraviolet spectra of these stars. “What is particularly surprising is that the existence of these molecules does not depend on the stellar temperature, but on the strength of the wind shocks” says Stanghellini.

The Small Magellanic cloud is particularly poor in metals (any element besides hydrogen and helium, in astronomers’ parlance) but this sort of environment favors the evolution of carbon rich-planetary nebulae, which turns out to be a favorable place for complex carbon molecules. The challenge has been to extract the evidence for graphene (planar C24) from Spitzer data. “The Spitzer Space Telescope has been amazingly important for studying complex organic molecules in stellar environments” says Stanghellini. “We are now at the stage of not only detecting fullerenes and other molecules, but starting to understand how they form and evolve in stars.” Shaw adds “We are planning ground-based follow up through the NOAO system of telescopes. We hope to find other molecules in planetary nebulae where fullerene has been detected to test some **physical processes that might help us understand the biochemistry of life.**”

Source: Has graphene been detected in space?

Candle flames contain millions of tiny diamonds

josep saldaña, August 19, 2011
tags: nano before nanotech + nanoparticles

The flickering flame of a candle has generated comparisons with the twinkling sparkle of diamonds for centuries, but new research has discovered the likeness owes more to science than the dreams of poets.

Professor Wuzong Zhou, Professor of Chemistry at the University of St Andrews has discovered tiny diamond particles exist in candle flames.

His research has made a scientific leap towards solving a mystery which has befuddled people for thousands of years.

Since the first candle was invented in ancient China more than 2,000 years ago, many have longed to know what hidden secrets its flames contained.

Professor Zhou's investigation revealed **around 1.5 million diamond nanoparticles are created every second in a candle flame as it burns.**

The leading academic revealed he uncovered the secret ingredient after a challenge from a fellow scientist in combustion.

Professor Zhou said: "A colleague at another university said to me: 'Of course no-one knows what a candle flame is actually made of.'"

"I told him I believed science could explain everything eventually, so I decided to find out."

Using a new sampling technique, assisted by his student Mr Zixue Su, he invented himself, he was able to remove particles from the centre of the flame – something never successfully achieved before – and found to his surprise that **a candle flame contains all four known forms of carbon.**

Professor Zhou said: "This was a surprise because each form is usually created under different conditions."

At the bottom of the flame, it was



Professor Wuzong Zhou seeing a candle. Credit: Courtesy of University of St Andrews

already known that hydro-carbon molecules existed which were converted into carbon dioxide by the top of the flame.

But the process in between remained a mystery.

Now both diamond nanoparticles and fullerenic particles have been discovered in the centre of the flame, along with graphitic and amorphous carbon.

The discovery could lead to future research into how diamonds, a key substance in industry, could be created more cheaply, and in a more environmentally friendly way.

Professor Zhou added: "Unfortunately the diamond particles are burned away in the process, and converted into carbon dioxide, but this will change the way we view a candle flame forever."

The famous scientist Michael Faraday in his celebrated 19th century lectures on "The Chemical History of a Candle" said in an 1860 address to the light: "You have the glittering beauty of gold

and silver, and the still higher lustre of jewels, like the ruby and diamond; but none of these rival the brilliancy and beauty of flame. What diamond can shine like flame?"

Rosey Barnet, Artistic Director of one of Scotland's biggest candle manufacturers, Shearer Candles, described the finding as "exciting".

She said: "We were thrilled to hear about the discovery that diamond particles exist in a candle flame.

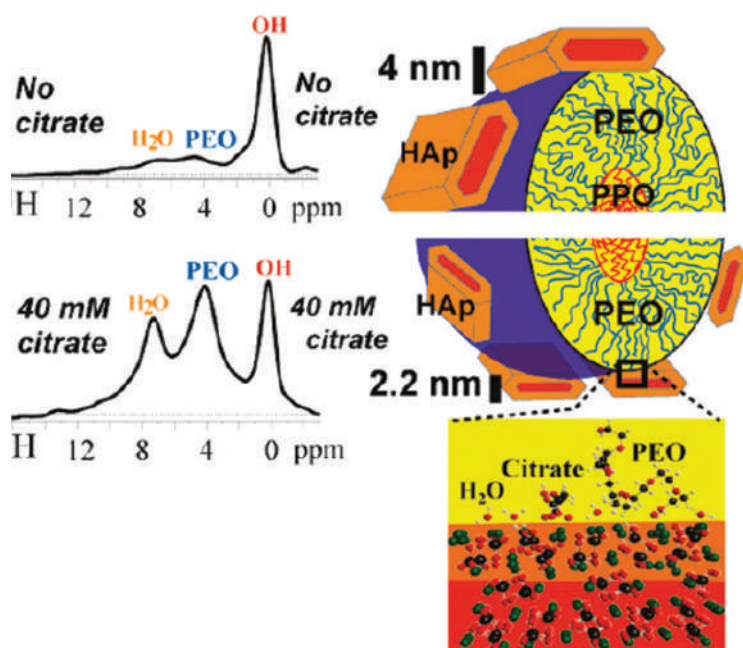
"Although currently there is no way of extracting these particles, it is still an exciting find and one that could change the way people view candles. The research at St Andrews University will be of interest to the entire candle making industry. We always knew candles added sparkle to a room but now scientific research has provided us with more insight into why."

Source: Candle flames contain millions of tiny diamonds

Bone's nanostructure

josep saldaña, June 9, 2011

tags: nanomedicine + nanomaterial+ nanominerals + nano before nanotech



This diagram shows the effect of citrate concentration on the size of hydroxyapatite crystals fabricated with self-assembling block copolymer templates. Just as it does with actual bone structure, as the concentration of citrate increases, the thickness of the nanocrystals decreases and the thinner nanocrystals appear to make the bone more resistant to stress cracking. Credit: U.S. Dept. of Energy's Ames Laboratory

Bone is one of nature's surprising "building materials." Pound-for-pound it's stronger than steel, tough yet resilient. Scientists **have identified the composition that gives bone its outstanding properties** and the important role citrate plays, work that may help science better understand and treat or prevent bone diseases such as osteoporosis.

Using nuclear magnetic resonance (NMR) spectroscopy, U.S. Department of Energy's Ames Laboratory scientist and Iowa State University chemistry professor Klaus Schmidt-Rohr and his colleagues studied **bone, an organic-inorganic nanocomposite whose stiffness is provided by thin nanocrystals of carbonated apatite, a calcium phosphate, imbedded in an organic matrix of mostly collagen, a fibrous protein.**

By understanding the nanostructure of naturally occurring materials, researchers may be able to develop new light-weight, high-strength materials that will require less energy to manufacture and that could make the products in which they are used more energy efficient.

"The organic, collagen matrix is what makes bones tough," Schmidt-Rohr said, "while the inorganic apatite nanocrystals provide the stiffness. And the small thickness – about 3 nanometers – of these nanocrystals appears to provide favorable mechanical properties, primarily in prevention of crack propagation." While bone structure has been studied extensively, **how these apatite nanocrystals form and what prevents them from growing thicker was a mystery.**

After studying bone structure over a five-year period, it was actually serendipitous that Schmidt-Rohr came across a signature that appeared to match what he was seeing. "We had gotten some crystalline collagen samples to study," he said, "and it turned out that the supplier had used citrate to dissolve the collagen. And the citrate signature in the collagen samples matched the signature we were seeing in bone."

According to Schmidt-Rohr, the role of citrate in bone had been studied up until about 1975, but since that time, no mention was made in any of the newer

literature on bone. So in essence, his research team had to rediscover it.

"We feel that citrate probably also has a role in the biomineralization of the apatite," Schmidt-Rohr said. "It's also been noted in the literature that as an organism ages, the nanocrystal thickness increases and the citrate concentration goes down," Schmidt-Rohr said, "and there's also support from clinical studies that citrate is good for bones," adding that one of the leading supplements for bone strength contains calcium citrate. "While calcium loss is a major symptom in osteoporosis, the decline of citrate concentration may also contribute to bone brittleness," he said. **Source: Citrate Key in Bone's Nanostructure.**

See also: The calcification at a nanometer scale. "Unravelling the processes of calcium phosphate formation is important in our understanding of both bone and tooth formation, and also of pathological mineralization, for example in cardiovascular disease."

New evidence for natural synthesis of silver nanoparticles

josep saldaña, May 13, 2011

tags: nano before nanotech + nanoparticles + nanosilver + nanotoxicology

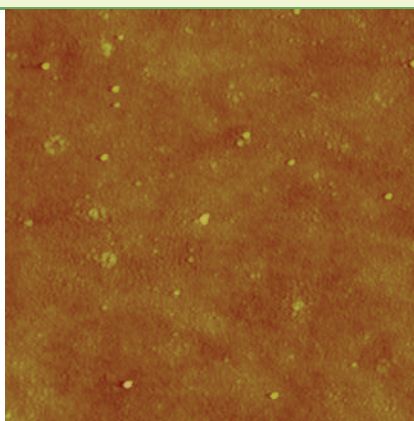
Nanoparticles of silver are being found increasingly in the environment—and in environmental science laboratories. Because they have a variety of useful properties, especially as antibacterial and antifungal agents, silver nanoparticles increasingly are being used in a wide variety of industrial and consumer products. This, in turn, has raised concerns about what happens to them once released into the environment. Now a new research paper adds an additional wrinkle: **Nature may be making silver nanoparticles on its own.**

A team of researchers from the Florida Institute of Technology (FIT), the State University of New York (SUNY), Buffalo, and the National Institute of Standards and Technology (NIST) reports that, **given a source of silver ions, naturally occurring humic acid will synthesize stable silver nanoparticles.**

“Our colleague, Virender Sharma, had read an article in which they were using wine to form nanoparticles. He thought that, based on the similar chemistry, we should be able to produce silver nanoparticles with humic acids,” explains FIT chemist Mary Sohn. “First we formed them by traditional methods and then we tried one of our river sediment humic acids. We were really excited that we could see the characteristic yellow color of the nanoparticles.” Samples were sent to Sarbajit Banerjee at SUNY Buffalo and Robert MacCuspie at NIST for detailed analyses to confirm the presence of silver nanoparticles.

“Humic acid” is a complex mixture of many organic acids that are formed during the decay of dead organic matter. Although the exact composition varies from place to place and season to season, humic acid is ubiquitous in the environment. Metallic nanoparticles, MacCuspie explains, have characteristic colors that are a direct consequence of their size. Silver nanoparticles appear a yellowish brown.

The team mixed silver ions with humic acid from a variety of sources at different temperatures and concentrations and found that acids from river water or sediments would form detectable silver nanoparticles at room temperature in as little as two to four days. Moreover,

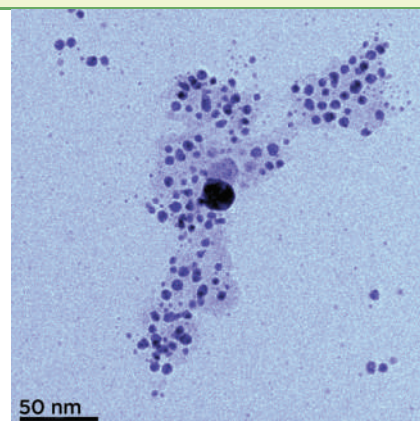


AFM (Atomic force microscopy) image of silver nanoparticles formed from silver ions in solution with humic acid. Color tone in this image indicates height (0 to 10 nanometers) above the base plane, so brighter spots are taller, larger nanoparticles. Image is roughly 1,700 nm on a side. Credit: MacCuspie, NIST

MacCuspie says, the humic acid appears to stabilize the nanoparticles by coating them and preventing the nanoparticles from clumping together into a larger mass of silver. “We believe it’s actually a similar process to how nanoparticles are synthesized in the laboratory,” he says, except that the lab process typically uses citric acid at elevated temperatures.

“This caught us by surprise because a lot of our work is focused on how silver nanoparticles may dissolve when they’re released into the environment and release silver ions,” MacCuspie says. Many biologists believe the toxicity of silver nanoparticles, the reason for their use as an antibacterial or antifungal agent, is due to their high surface area that makes them an efficient source of silver ions, he says, but “this creates the idea that there may be some sort of natural cycle returning some of the ions to nanoparticles.” It also helps explain the discovery, over the past few years, of silver nanoparticles in locations like old mining regions that are not likely to have been exposed to man-made nanoparticles, but would have significant concentrations of silver ions.

Source: Silver Cycle: New Evidence for Natural Synthesis of Silver Nanoparticles. This work was detailed in the paper **Humic acid-induced silver nanoparticle formation under environmentally relevant conditions**



TEM (Transmission electron microscopy) image of silver nanoparticles formed from silver ions in solution with humic acid. The acid tends to coat the nano particles (visible here as a pale cloud), keeping them in a colloidal suspension instead of clumping together. (Color added for clarity.)

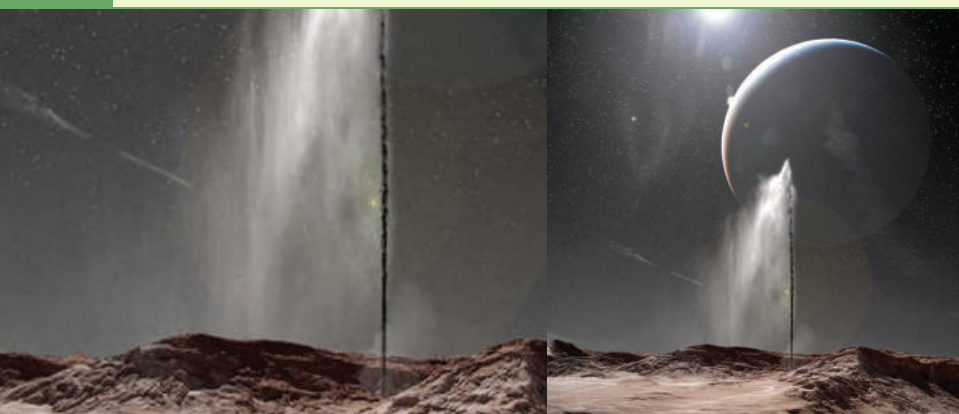
Abstract: Nelson Akaighe, Robert I. MacCuspie, Divina A. Navarro, Diana S. Aga, Sarbajit Banerjee, Mary Sohn, and Virender K. Sharma. 2011. **Environmental Science & Technology** doi:10.1021/es103946g

The formation of silver nanoparticles (AgNPs) via reduction of silver ions (Ag⁺) in the presence of humic acids (HAs) under various environmentally relevant conditions is described. HAs tested originated from the Suwannee River (SUW), and included samples of three sedimentary HAs (SHAs), and five soils obtained across the state of Florida. The time required to form AgNPs varied depending upon the type and concentration of HA, as well as temperature. SUW and all three SHAs reduced Ag⁺ at 22°C. However, none of the soil HAs formed absorbance-detectable AgNPs at room temperature when allowed to react for a period of 25 days, at which time experiments were halted. The appearance of the characteristic surface plasmon resonance (SPR) of AgNPs was observed by ultraviolet–visible spectroscopy in as few as 2–4 days at 22°C for SHAs and SUW. An elevated temperature of 90°C resulted in the accelerated appearance of the SPR within 90 min for SUW and all SHAs. The formation of AgNPs at 90°C was usually complete within 3 h. Transmission electron microscopy and atomic force microscopy images showed that the AgNPs formed were typically spherical and had a broad size distribution. Dynamic light scattering also revealed polydisperse particle size distributions. HAs appeared to colloiddally stabilize AgNPs based on lack of any significant change in the spectral characteristics over a period of two months. The results suggest the potential for direct formation of AgNPs under environmental conditions from Ag⁺ sources, implying that not all AgNPs observed in natural waters today may be of anthropogenic origin.

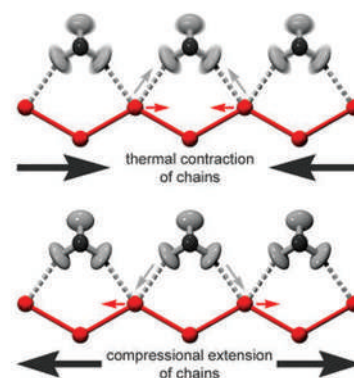
Study of volcanoes in the outer solar system produces unexpected bonus for nanotechnology

josep saldaña, February 14, 2011

tags: astronomy + nano before nanotech + nanomaterial + nanoelectronics



An artists impression of a volcanic eruption on Triton. Copyright D. Fortes



This unexpected expansion (elongating and thinning) under uniform pressure is known as negative linear compressibility

Mysterious expanding ice crystals in the moons of Saturn and Neptune may be of interest to future developers of microelectronics. Neutron scattering has discovered that methanol crystals that may be found in outer solar system 'ice lavas' have unusual expansion properties. The unexpected finding by a British planetary geologist using neutrons at the Institut Laue-Langevin and the STFC ISIS neutron source will interest developers of 'nano-switches' – single atom thick valves used in 'micro-electronics' at the nano scale.

Dr Dominic Fortes, UCL (University College London) made the discovery whilst investigating the internal structure of icy moons, such as Neptune's Triton, to explain the icy eruptions seen by passing space-craft. By studying the behaviour of methanol monohydrate, a known constituent of outer solar system ice, under conditions like those within the moons' interiors Fortes hoped to understand its role in volcanism.

Fortes measured structural changes in methanol crystals over a range of temperatures and pressures. He found that when heated at room pressure they would expand enormously in one direction whilst shrinking in the other two dimensions. However when heated under an even pressure they expanded in two directions, whilst compressing in the third. This unexpected expansion (elongating and thinning) under uniform pressure is known as negative linear compressibility (NLC).

Whilst these results form the next step

towards understanding outer solar system volcanic activity, Fortes' discovery is of significant interest for material scientists developing nanotechnology. The predictable expansion of NLC materials in a particular direction under pressure makes them a good candidate for nano-switches where their shape-shifting properties can be used like a microscopic, pressure-controlled valve directing the flow of electricity.

NLC materials are extremely rare with only around 15 known examples. What causes this property is still relatively unknown. Scientists hope better understanding of the phenomenon can bring forward potential technological application.

"Currently the use of NLC materials in technologies such as nano-switches is purely theoretical and limited by our lack of understanding of the underlying physics", says Prof. Reinhard Neder chairman of the ILL crystallographic committee who approved Dr Fortes beam-time at the world's flagship centre for neutron science. "However, the simple structure of methanol monohydrate gives us a good chance to understand the source of this property and how to look for it in other more commercially viable materials."

"It was certainly unexpected," explains Dr Fortes. "As a planetary geologist my focus is understanding the mechanisms behind volcanic eruptions in the outer solar system. If my results open doors for more applied science back on Earth, that's a bonus."

Professor Richard Wagner, Director at the Institut Laue Langevin added "This research is a good example of how even basic academic studies can have completely unpredictable benefits in other areas of science and technology. It's because of discoveries like this that the ILL strives to maintain our delivery of world leading neutron science in both 'fundamental' and 'applied' fields."

Source: Study of volcanoes in the outer solar system produces unexpected bonus for nanotechnology. This work is detailed in the paper **Negative Linear Compressibility and Massive Anisotropic Thermal Expansion in Methanol Monohydrate** by A. Dominic Fortes, Emmanuelle Suard, and Kevin S. Knight

Abstract: The vast majority of materials shrink in all directions when hydrostatically compressed; exceptions include certain metallic or polymer foam structures, which may exhibit negative linear compressibility (NLC) (that is, they expand in one or more directions under hydrostatic compression). Materials that exhibit this property at the molecular level—crystalline solids with intrinsic NLC—are extremely uncommon. With the use of neutron powder diffraction, we have discovered and characterized both NLC and extremely anisotropic thermal expansion, including negative thermal expansion (NTE) along the NLC axis, in a simple molecular crystal (the deuterated 1:1 compound of methanol and water). Apically linked rhombuses, which are formed by the bridging of hydroxyl-water chains with methyl groups, extend along the axis of NLC/NTE and lead to the observed behavior.

120 years of nanosilver history

josep saldaña, February 3, 2011

tags: nano before nanotech + nanoparticles + nanosilver + regulation + nanotoxicology

Nanosilver is not a new discovery by nanotechnologists – it has been used in various products for over a hundred years, as is shown by a new Empa study. The antimicrobial effects of minute silver particles, which were then known as “colloidal silver”, were known from the earliest days of its use.

Numerous nanomaterials are currently at the focus of public attention. In particular silver nanoparticles are being investigated in detail, both by scientists as well as by the regulatory authorities. The assumption behind this interest is that they are dealing with a completely new substance. However, Empa researchers Bernd Nowack and Harald Krug, together with Murray Heights of the company HeiQ have shown in a paper recently published in the journal «Environmental Science & Technology» that nanosilver is by no means the discovery of the 21st century. Silver particles with diameters of seven to nine nm were mentioned as early as 1889. They were used in medications or as biocides to prevent the growth of bacteria on surfaces, for example in antibacterial water filters or in algicides for swimming pools.

The material has always been the same

The nanoparticles were known as “colloidal silver” in those days, but what was meant was the same then as now – extremely small particles of silver. The only new aspect is the use today of the prefix “nano”. “However,” according to Bernd Nowack, “nano does not mean something new, and nor does it mean something that is harmful.” When “colloidal silver” became available on the market in large quantities in the 1920s it was the topic of numerous studies and subject to appropriate regulation by the authorities. Even in those days the significance of the discovery of nanoparticles and how they worked was realized. “That is not to say that the possible side-effects of nanoparticles on humans and the environment should be played down or ignored,” adds Nowack. It is important to characterize in exact detail the material properties of nanosilver and not just to believe unquestioningly the doubts and reservations surrounding the product.

Nanosilver has different effects than silver

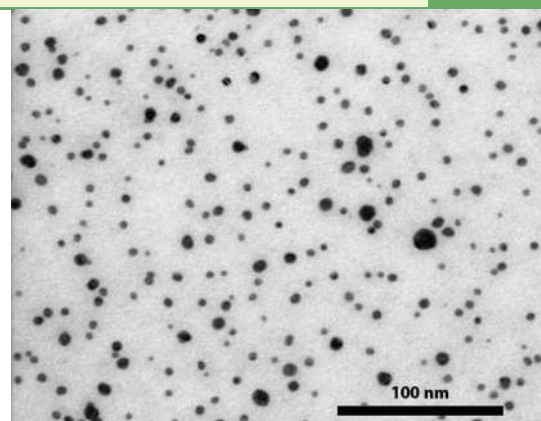
The term nanoparticle is understood

to refer to particles whose dimensions are less than 100 nm. Because of their minute size nanoparticles have different properties than those of larger particles of the same material. For example, for a given volume nanoparticles have a much greater surface area, so they are frequently much more reactive than the bulk material. In addition, even in small quantities nanosilver produces more silver ions than solid silver. These silver ions are toxic to bacteria. Whether or not nanosilver represents a risk to humans and the environment is currently the subject of a great deal of investigation.

Nanosilver in wastewater treatment plants

Currently there are hundreds of products in circulation which contain silver nanoparticles. Examples include cosmetics, food packaging materials, disinfectants, cleaning agents and – not least – antibacterial socks and underwear. Every year some 320 tonnes of nanosilver are used worldwide, some of which is released into wastewater, thus finding its way into natural water recirculation systems. What effects silver particles have on rivers, soil and the organisms that live in them has not yet been clarified in detail. A commentary by Bernd Nowack in the scientific journal “Science” discusses the implications of the newest studies on nanosilver in sewage treatment plants. More than 90% remains bound in the sewage sludge in the form of silver sulfide, a substance which is extremely insoluble and orders of magnitude less poisonous than free silver ions. It apparently does not matter what the original form of the silver in the wastewater was, whether as metallic nanoparticles, as silver ions in solution or as precipitated insoluble silver salts. “As far as the environmental effects are concerned, it seems that nanosilver in consumer goods is no different than other forms of silver and represents only a minor problem for eco-systems,” says Nowack. What is still to be clarified, however, is in what form the unbound silver is present in the treated water released from sewage works, and what happens to the silver sulfide in natural waters. Is this stable and unreactive or is it transformed into other forms of silver?

Source: At work against microbes for over a century. Nanosilver: a new name – well known effects. This work was detailed in the paper **120 Years of Nanosilver History: Implications for**



TEM image of silver nanoparticles in the algicide Algaedyn used for swimming pools

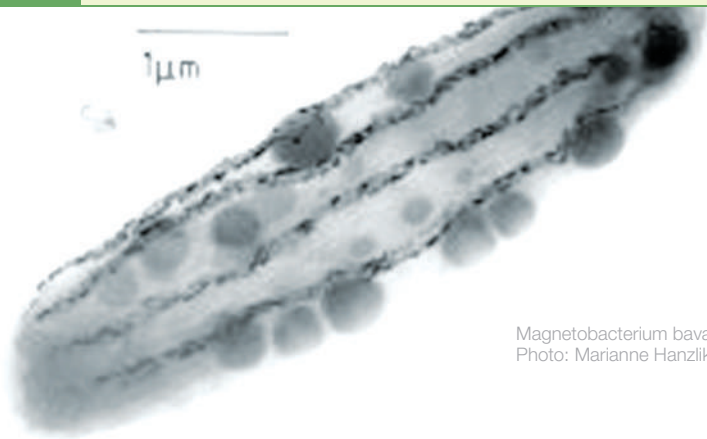
Policy Makers by Bernd Nowack, Harald F. Krug, Murray Height

Abstract: Nanosilver is one nanomaterial that is currently under a lot of scrutiny. Much of the discussion is based on the assumption that nanosilver is something new that has not been seen until recently and that the advances in nanotechnology opened completely new application areas for silver. However, we show in this analysis that nanosilver in the form of colloidal silver has been used for more than 100 years and has been registered as a biocidal material in the United States since 1954. Fifty-three percent of the EPA-registered biocidal silver products likely contain nanosilver. Most of these nanosilver applications are silver-impregnated water filters, algicides, and antimicrobial additives that do not claim to contain nanoparticles. Many human health standards for silver are based on an analysis of argyria occurrence (discoloration of the skin, a cosmetic condition) from the 1930s and include studies that considered nanosilver materials. The environmental standards on the other hand are based on ionic silver and may need to be re-evaluated based on recent findings that most silver in the environment, regardless of the original silver form, is present in the form of small clusters or nanoparticles. The implications of this analysis for policy of nanosilver is that it would be a mistake for regulators to ignore the accumulated knowledge of our scientific and regulatory heritage in a bid to declare nanosilver materials as new chemicals, with unknown properties and automatically harmful simply on the basis of a change in nomenclature to the term “nano”.

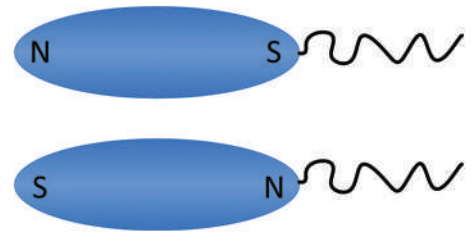
How bacterial magnetosomes form

josep saldaña, January 17, 2011

tags: nano before nanotech + nanomedicine + nanobiotechnology



Magnetobacterium bavaricum.
Photo: Marianne Hanzlik



The MTB polarity model

Magnetotactic bacteria found in the muddy bottoms of ponds and lakes use the Earth's magnetic field to distinguish up from down, allowing them to seek out optimal conditions for growth and survival (Biomagnetism). The sensors are called magnetosomes, each comprising an ordered microscopic crystal of an iron oxide (magnetite) or sulfide (greigite) enclosed in a specialized pocket formed by a fold in the cell membrane. Magnetosomes are arranged in linear chains, so that the nanomagnets they contain act as compass needles that enable the cells to follow geomagnetic field lines

Only a few of these magnetotactic bacteria species grow readily in laboratory cultures. A research team led by LMU microbiologists Dr. Christian Jogler and Professor Dirk Schüler, in cooperation with the Max Planck Institutes for Molecular Genetics (Berlin) and Marine Microbiology (Bremen), has now used a magnetic trap to isolate one such species, *Magnetobacterium bavaricum*, directly from sediments dredged from the Chiemsee (a lake in Southern Bavaria). *M. bavaricum* is of special interest because it is unusually large and contains very many minimagnets. The investigators then compared selected DNA sequences from *M. bavaricum* with those of

other known magnetic bacteria. The results show, for the first time, that the genes required for the assembly of bacterial compasses derive from a single source, although they are now found in widely divergent groups. "The genes were most probably transmitted between otherwise unrelated groups by horizontal gene transfer," says Schüler. **In many respects the properties of the biomagnets in magnetosomes make them more suitable for many applications in medical diagnostics and therapy than chemically synthesized nanomagnets.** The mechanism of magnetosome formation is therefore of considerable biotechnological interest.

Source: A trend-setting direction finder. The bacterial minicompass was invented only once. This work was detailed in the paper **Conservation of proteobacterial magnetosome genes and structures in an uncultivated member of the deep-branching Nitrospira phylum** by Christian Jogler, Gerhard Wanner, Sebastian Kolinko, Martina Niebler, Rudolf Amann, Nikolai Petersen, Michael Kube, Richard Reinhardt, and Dirk Schüler

Abstract: Magnetotactic bacteria (MTB) are a phylogenetically diverse group which uses intracellular membrane-enclosed magnetite

crystals called magnetosomes for navigation in their aquatic habitats. Although synthesis of these prokaryotic organelles is of broad interdisciplinary interest, its genetic analysis has been restricted to a few closely related members of the Proteobacteria, in which essential functions required for magnetosome formation are encoded within a large genomic magnetosome island. However, because of the lack of cultivated representatives from other phyla, it is unknown whether the evolutionary origin of magnetotaxis is monophyletic, and it has been questioned whether homologous mechanisms and structures are present in unrelated MTB. Here, we present the analysis of the uncultivated "Candidatus *Magnetobacterium bavaricum*" from the deep branching Nitrospira phylum by combining micromanipulation and whole genome amplification (WGA) with metagenomics. Target-specific sequences obtained by WGA of cells, which were magnetically collected and individually sorted from sediment samples, were used for PCR screening of metagenomic libraries. This led to the identification of a genomic cluster containing several putative magnetosome genes with homology to those in Proteobacteria. A variety of advanced electron microscopic imaging tools revealed a complex cell envelope and an intricate magnetosome architecture. The presence of magnetosome membranes as well as cytoskeletal magnetosome filaments suggests a similar mechanism of magnetosome formation in "Cand. *M. bavaricum*" as in Proteobacteria. Altogether, our findings suggest a monophyletic origin of magnetotaxis, and relevant genes were likely transferred horizontally between Proteobacteria and representatives of the Nitrospira phylum.

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Photobactericidal porphyrin-cellulose nanocrystals: synthesis, characterization, and antimicrobial properties

by Elke Feese¹, Hasan Sadeghifar^{2,5}, Hanna S. Gracz³, Dimitris S. Argyropoulos^{1,2,4} and Reza A. Ghiladi¹
Biomacromolecules 2011, 12, 3528–3539 doi: dx.doi.org/10.1021/bm200718s

- 1 Departments of Chemistry, 2Forest Biomaterials, and 3Molecular and Structural Biochemistry, North Carolina State University, Raleigh, North Carolina, United States
- 4 Department of Chemistry, University of Helsinki, Helsinki, Finland
- 5 Department of Wood and Paper Science, Islamic Azad University, Chalous, Iran

Biomimetic self-templating supramolecular structures

by Woo-Jae Chung^{1,2}, Jin-Woo Oh^{1,2}, Kyungwon Kwak^{1,2}, Byung Yang Lee^{1,2}, Joel Meyer², Eddie Wang^{1,2}, Alexander Hexemer³ & Seung-Wuk Lee
Nature 478, 364–368doi: 10.1038/nature10513

- 1 Department of Bioengineering, University of California, Berkeley, California 94720, USA
- 2 Physical Biosciences Division, Lawrence Berkeley National Laboratory, Berkeley, California 94720, USA
- 3 Advanced Light Source, Lawrence Berkeley National Laboratory, Berkeley, California 94720, USA

Generation of Metal Nanoparticles from Silver and Copper Objects: Nanoparticle Dynamics on Surfaces and Potential Sources of Nanoparticles in the Environment

by Richard D. Glover¹, John M. Miller², and James E. Hutchison^{1,2}
ACS Nano, 2011, 5 (11), pp 8950–8957 doi: 10.1021/nn2031319

- 1 Department of Chemistry and Materials Science Institute, 1253 University of Oregon, Eugene, Oregon 97403, United States,
- 2 Dune Sciences, Inc., 1900 Millrace Drive, Eugene, Oregon 97403, United States

The Formation of Fullerenes: Clues from New C₆₀, C₇₀, and (Possible) Planar C₂₄ Detections in Magellanic Cloud Planetary Nebulae

by D. A. García-Hernández^{1,2}, S. Iglesias-Groth^{1,2}, J. A. Acosta-Pulido^{1,2}, A. Manchado^{1,2,3}, P. García-Lario⁴, L. Stanghellini⁵, E. Villaver⁶, R. A. Shaw⁵ and F. Cataldo^{7,8}
ApJ 737 L30 doi:10.1088/2041-8205/737/2/L30

- 1 Instituto de Astrofísica de Canarias, 38200 La Laguna, Spain
- 2 Departamento de Astrofísica, Universidad de La Laguna (ULL), E-38205 La Laguna, Spain
- 3 Consejo Superior de Investigaciones Científicas, Spain
- 4 Herschel Science Centre, European Space Astronomy Centre, Research and Scientific Support Department of ESA, Villafranca del Castillo, E-28080 Madrid, Spain
- 5 National Optical Astronomy Observatory, Tucson, AZ 85719, USA
- 6 Departamento de Física Teórica C-XI, Universidad Autónoma de Madrid, E-28049 Madrid, Spain
- 7 Istituto Nazionale di Astrofisica-Osservatorio Astrofisico di Catania, 95123 Catania, Italy
- 8 Actinium Chemical Research, 00133 Rome, Italy

New insight into the soot nanoparticles in a candle flame

by Zixue Su, Wuzong Zhou and Yang Zhang
Chemical Communications. 47, 16, p. 4700–4702. doi: 10.1039/C0CC05785A
Centre for Higher Education Research, University of St Andrews, Scotland

Biomimetic Self-Assembling Copolymer–Hydroxyapatite Nanocomposites with the Nanocrystal Size Controlled by Citrate

by Y.-Y. Hu, X. P. Liu, X. Ma, A. Rawal, T. Prozorov, M. Akinc, S. K. Mallapragada, and K. Schmidt-Rohr
Chem. Mater., 2011, 23 (9), pp 2481–2490 doi: 10.1021/cm200355n
Ames Laboratory, Ames, Iowa 50011, United States

Humic acid-induced silver nanoparticle formation under environmentally relevant conditions

by Nelson Akaighe¹, Robert I. MacCuspie², Divina A. Navarro³, Diana S. Aga³, Sarbajit Banerjee³, Mary Sohn¹, and Virender K. Sharma¹

Environmental Science & Technology doi:10.1021/es103946g

1 Chemistry Department, Florida Institute of Technology, 150 West University Boulevard, Melbourne, Florida 32901, United States.

2 Material Measurement Laboratory, National Institute of Standards and Technology, 100 Bureau Drive, Stop 8520, Gaithersburg, Maryland 20899-8520, United States.

3 Department of Chemistry, 410 Natural Sciences Complex, University at Buffalo, The State University of New York, Buffalo, New York 14260-3000, United States.

Negative Linear Compressibility and Massive Anisotropic Thermal Expansion in Methanol Monohydrate

by A. Dominic Fortes^{1,2}, Emmanuelle Suard³, and Kevin S. Knight^{4,5}

Science Vol. 331 no. 6018 pp. 742-746 doi: 10.1126/science.1198640

1 Department of Earth Sciences, University College London (UCL), Gower Street, London WC1E 6BT, UK.

2 Centre for Planetary Sciences at UCL/Birkbeck, Gower Street, London WC1E 6BT, UK.

3 Institut Laue-Langevin (ILL), BP156, 38042 Grenoble cedex 9, France.

4 ISIS Facility, Science and Technology Facilities Council (STFC) Rutherford Appleton Laboratory, Harwell Science and Innovation Campus, Chilton, Didcot, Oxfordshire OX11 0QX, UK.

5 The Natural History Museum, Cromwell Road, London SW7 5BD, UK.

“120 Years of Nanosilver History: Implications for Policy Makers”

by Bernd Nowack¹, Harald F. Krug¹, and Murray Height²

Environ. Sci. Technol., 2011, 45 (4), pp 1177–1183 doi: 10.1021/es103316q

1 EMPA – Swiss Federal Laboratories for Materials Science and Technology, Lerchenfeldstrasse 5, CH-9014 St. Gallen, Switzerland.

2 HeiQ Materials AG, CH-5330 Bad Zurzach, Switzerland.

“Conservation of proteobacterial magnetosome genes and structures in an uncultivated member of the deep-branching Nitrospira phylum”

by Christian Joglera¹, Gerhard Wanner¹, Sebastian Kolinko¹, Martina Niebler¹, Rudolf Amann², Nikolai Petersen¹, Michael Kubec³, Richard Reinhardt³, and Dirk Schülere¹

PNAS December 29, 2010 doi: 10.1073/pnas.1012694108

1 Ludwig Maximilians University, 82152 Munich, Germany.

2 Max Planck Institute for Marine Microbiology, 28359 Bremen, Germany.

3 Max Planck Institute for Molecular Genetics, 14195 Berlin, Germany.

Institutions - Country

Actinium Chemical Research,
00133 Rome, Italy

Advanced Light Source, Lawrence Berkeley National Laboratory,
Berkeley, California 94720, USA

Ames Laboratory,
Ames, Iowa 50011, United States

Centre for Higher Education Research,
University of St Andrews, Scotland

Centre for Planetary Sciences at UCL/Birkbeck,
Gower Street, London WC1E 6BT, UK

Chemistry Department, Florida Institute of Technology,
150 West University Boulevard, Melbourne, Florida 32901, United States

Consejo Superior de Investigaciones Científicas,
Spain

Departamento de Astrofísica, Universidad de La Laguna (ULL),
E-38205 La Laguna, Spain

Departamento de Física Teórica C-XI, Universidad Autónoma de Madrid,
E-28049 Madrid, Spain

Department of Bioengineering, University of California, Berkeley,
California 94720, USA

Department of Chemistry and Materials Science Institute, 1253 University of Oregon,
Eugene, Oregon 97403, United States

Department of Chemistry, 410 Natural Sciences Complex, University at Buffalo, The State University of New York, Buffalo,
New York 14260-3000, United States

Department of Chemistry, University of Helsinki,
Helsinki, Finland

Department of Earth Sciences, University College London (UCL),
Gower Street, London WC1E 6BT, UK

Department of Wood and Paper Science, Islamic Azad University,
Chalous, Iran

Departments of Chemistry, Forest Biomaterials, and Molecular and Structural Biochemistry, North Carolina State University,
Raleigh, North Carolina, United States

Dune Sciences, Inc.,

1900 Millrace Drive, Eugene, Oregon 97403, United States

EMPA – Swiss Federal Laboratories for Materials Science and Technology,

Lerchenfeldstrasse 5, CH-9014 St. Gallen, Switzerland

HeiQ Materials AG,

CH-5330 Bad Zurzach, Switzerland

**Herschel Science Centre, European Space Astronomy Centre, Research and Scientific Support
Department of ESA,**

Villafranca del Castillo, E-28080 Madrid, Spain

Institut Laue-Langevin (ILL),

BP156, 38042 Grenoble cedex 9, France

Instituto de Astrofísica de Canarias,

38200 La Laguna, Spain

**ISIS Facility, Science and Technology Facilities Council (STFC) Rutherford Appleton Laboratory, Harwell
Science and Innovation Campus, Chilton,**

Didcot, Oxfordshire OX11 0QX, UK

Istituto Nazionale di Astrofisica-Osservatorio Astrofisico di Catania,

95123 Catania, Italy

Ludwig Maximilians University,

82152 Munich, Germany

Material Measurement Laboratory, National Institute of Standards and Technology,

100 Bureau Drive, Stop 8520, Gaithersburg, Maryland 20899-8520, United States

Max Planck Institute for Marine Microbiology,

28359 Bremen, Germany

Max Planck Institute for Molecular Genetics,

14195 Berlin, Germany

National Optical Astronomy Observatory,

Tucson, AZ 85719, USA

Physical Biosciences Division, Lawrence Berkeley National Laboratory,

Berkeley, California 94720, USA

The Natural History Museum,

Cromwell Road, London SW7 5BD, UK

Authors List

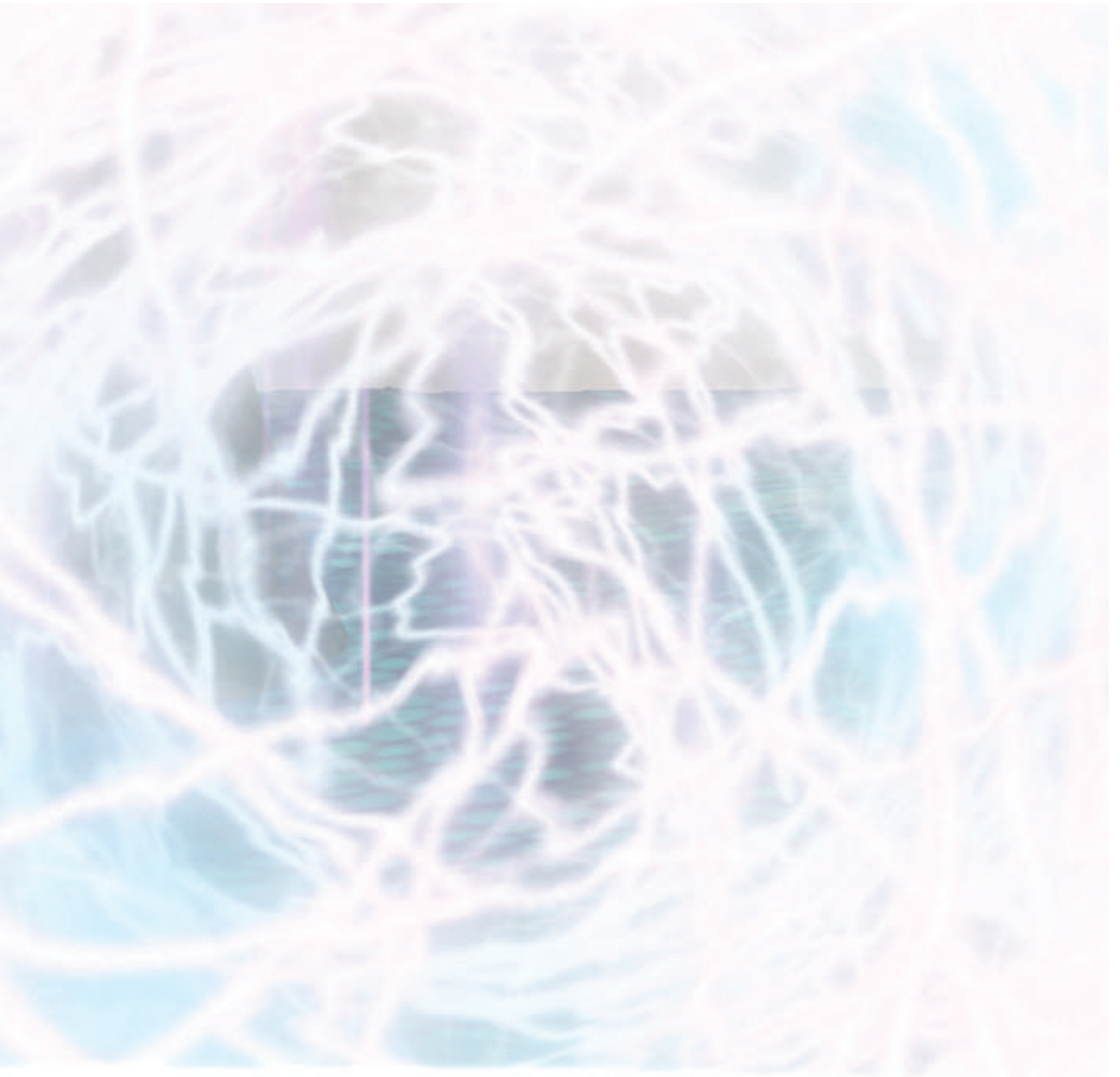
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Amannb, Rudolf	Sadeghifar, Hasan
Argyropoulos, Dimitris S.	Schmidt-Rohr, K.
Banerjee, Sarbajit	Schülera, Dirk
Cataldo, F.	Sharma, Virender K
Chung, Woo-Jae	Shaw, R. A.
Dominic Fortes, A.	Sohn, Mary
Feese, Elke	Stanghellini, L.
García-Hernández, D. A.	Su, Zixue
García-Lario, P.	Suard, Emmanuelle
Ghiladi, Reza A.	Villaver, E.
Glover, Richard D.	Wang, Eddie
Gracz, Hanna S.	Wannera, Gerhard
Height, Murray	Yang Lee, Byung
Hexemer, Alexander	Zhang, Yang
Hu, Y.-Y.	Zhou, Wuzong
Hutchison, James E.	
Iglesias-Groth, S.	
Joglera, Christian	
Knight, Kevin S.	
Kolinkoa, Sebastian	
Krug, Harald F.	
Kubec, Michael	
Kwak, Kyungwon	
Lee, Seung-Wuk	
Liu, X. P.	
Ma, X.	
MacCusprie, Robert I.	
Mallapragada, S. K.	
Manchado, A.	
Meyer, Joel	
Miller, John M.	
Navarro, Divina A.	
Nieblera, Martina	
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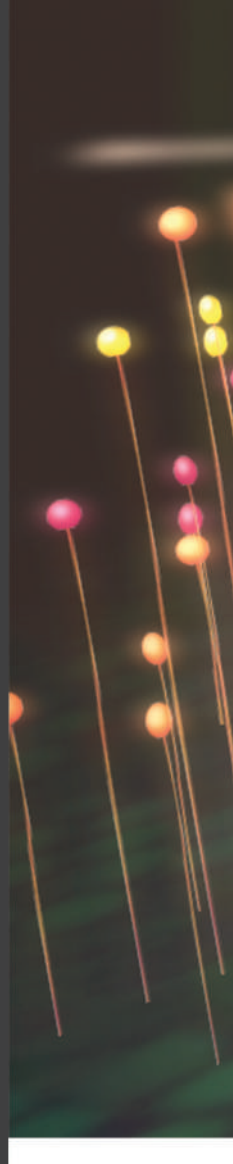
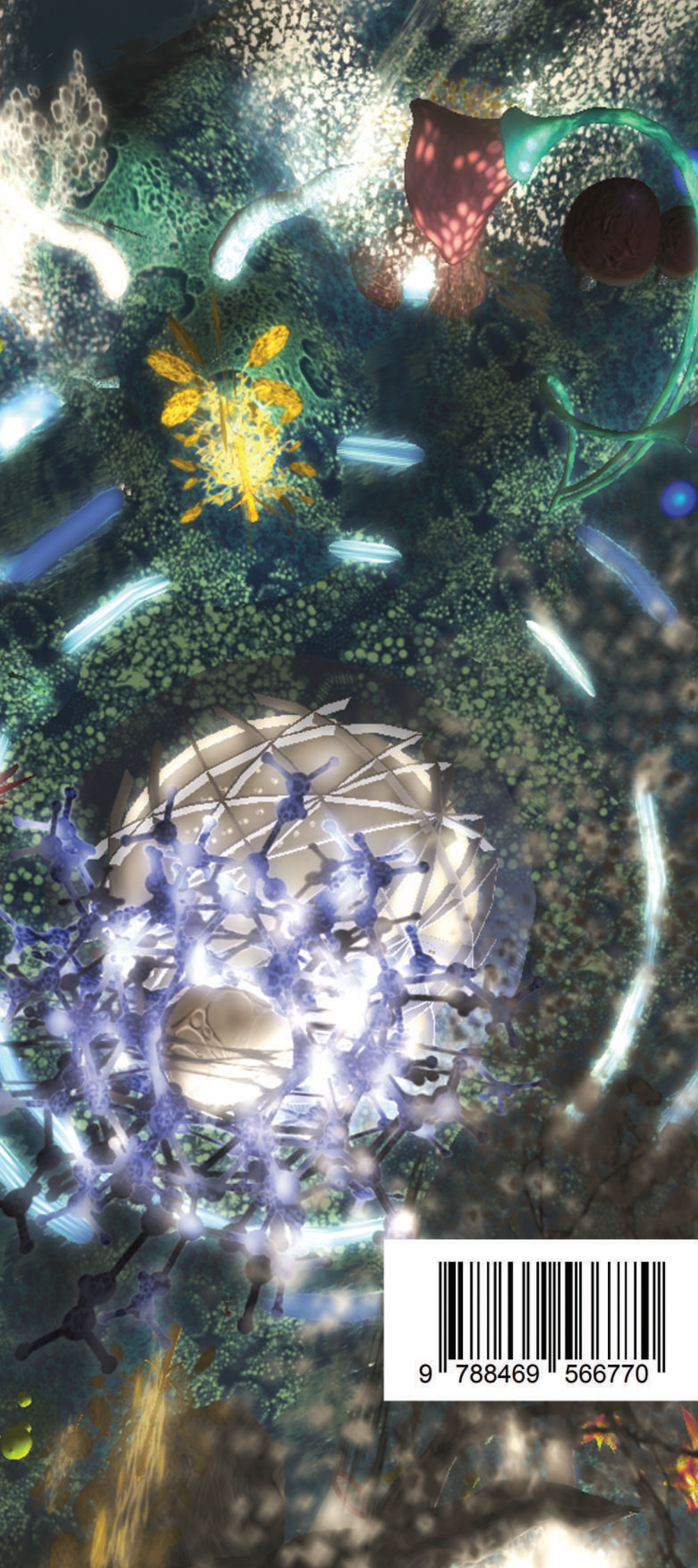
Epilogue

Finding the occasional straw of truth awash in a great ocean of confusion and bamboozle requires intelligence, vigilance, dedication and courage. But if we don't practice these tough habits of thought, we cannot hope to solve the truly serious problems that face us -- and we risk becoming a nation of suckers, up for grabs by the next charlatan who comes along.

[Carl Sagan, The Fine Art of Baloney Detection]







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