has not routinely tracked flu-like illnesses in the past and does not have the resources to start now, Behrens commented. "We're keen to contribute," he said, but a significant increase in flu surveillance would require more money and manpower. Right now, he continued, "we are running at our maximum on the few diseases that we currently monitor".

Jelinek and Behrens stressed that the biggest challenge facing TropNetEurop in the future is the lack of secure funding. It is a private organization with no ties to any European government, and it relies entirely on the goodwill of its members. "This is one of the weaknesses [of TropNetEurop]," said Behrens, "but it is also one of the strengths in the sense that everybody who [participates] is committed to doing it for the benefit of everybody else." Jelinek and Behrens are hopeful that they might eventually receive support from the European Centre for Disease Prevention and Control in Solna, Sweden. Until then Behrens fears that TropNet-Europ will continue to be "vulnerable to pressures of time and resources".

GeoSentinel has better financial security, thanks to support from the CDC and the ISTM, but it has experienced some growing pains as it expands its international reach. Some countries are nervous about having a GeoSentinel site because they are concerned that it will disrupt reporting to their national health authorities. "All of our sites sign an agreement that no obligation to report to GeoSentinel supersedes their obligation to report...to the appropriate public health authorities within their own countries," Freedman said. GeoSentinel reports informally to the World Health Organization (WHO; Geneva, Switzerland), as does TropNet-Europ, but the WHO has been reluctant to establish closer ties. As Jelinek put it, "whether [the WHO] acts on [the networks' information] or what they do with it is left to them." The WHO's main mission, said Freedman, is to work with national health authorities and it does not want to become too involved with organizations that might be perceived as bypassing those authorities.

The CDC, by contrast, has collaborated closely with GeoSentinel from the beginning. In fact, the central database of the network is located at the CDC headquarters in Atlanta, although it is maintained by

GeoSentinel employees. The CDC has both received information from GeoSentinel and used its network to relay news about urgent situations to the infectious disease community. "Having a network of travel clinics around the world that are linked with rapid communication is really a vital asset to be able to tap into," said Paul Arguin, Chief of the Domestic Response Unit in the CDC's Malaria Branch. He believes that health authorities, particularly in smaller countries, could benefit from GeoSentinel's surveillance because it pools data from around the world and makes it possible to detect outbreaks that might not be obvious from looking at isolated cases within a single country.

Others in the infectious disease community agree. Herbert DuPont, Director of the Center for Infectious Diseases at the

University of Texas's Health Science Center (Houston, USA), calls GeoSentinel and TropNetEurop "terrific programs and the right step towards near real-time surveillance. They are early in their development and need time and additional sites to be the best they can be."

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doi:10.1038/sj.embor.7400797

Nanoregulation

A recent scare involving nanotech products reveals that the technology is not yet properly regulated

In March this year, the German and then the international press reported that people had become sick after using Magic-Nano products (Kleinmann GmbH; Sonnenbuehl, Germany): aerosols designed to coat glass and ceramic with a protective, dirt-repellent film. Within days, about 100 consumers became ill with symptoms such as coughing, headaches, sleep disruption and vomiting. A small number were hospitalized with pulmonary oedema, but most recovered in a matter of days. The health scare renewed fears of nanotech products in Germany, the only country where the product was marketed, and the press had a field day reporting on the first "nanorecall" as authorities pulled the product from the shelves.

... the first 'nano scare' did not actually involve any nanoparticles

After investigation, the German government and Kleinmann's supplier, Nanopool GmbH (Schwalbach, Germany), concluded

that the problem was not with the nano-components of the aerosol. According to René Zimmer of the Federal Institute for Risk Assessment in Berlin, Germany, "In the Magic-Nano case, not only no nanoparticles but also no silanes [the substance responsible for creating a nano-structured surface] were inside the bottle." Ralf Jürgens, a senior technologist with Nanopool, said the problem apparently related to pH levels in the aerosol: for still unexplained reasons, the original pH of the formulation was 2.4, which was increased to almost 8 through the addition of NaOH. The silica then sedimented as a white powder on the bottom of the container, "so the bottles that went to the stores didn't contain any silicon, silanes or silicon dioxide. And without silanes... there is no nanolayer/nanocoating which turns a substrate into a hydrophobic surface," said Jürgens. He noted that as consumers "sprayed like hell", they released an ultrafine aerosol mist containing ethanol and water, which irritated their lungs.

So the first 'nano scare' did not actually involve any nanoparticles. But the incident did raise questions about the risks posed by these new products, and prompted calls for regulation. "The world's most powerful emerging technology is developing in an almost total political and regulatory vacuum," said Pat Mooney, Executive Director of the ETC Group, a non-government environmental organization in Ottawa, Canada. "Because nanoscale technologies can be applied to virtually every industrial sector, no regulatory body is taking the lead. And because many of its products are nanosized versions of conventional compounds, regulatory scrutiny has been deemed unnecessary." In 2003, the ETC Group called for a moratorium on nanotechnology, warning that regulators were overlooking the risks of the technology (ETC Group, 2003).

In any case, the genie is out of the bottle. According to an online 'Nanotechnology Consumer Products Inventory' from the Project on Emerging Nanotechnologies, based at the Woodrow Wilson International Center for Scholars (Washington, DC, USA), more than 200 nanoproducts are on the market, including cosmetics and sunscreens, wound dressing, fuel additives, sports gear, anti-graffiti paints, foods, cleansers, stain-resistant clothing, cigarette filters, a pregnancy test, computer hardware, and anti-microbial coatings for mobile phones, condoms, refrigerators, washing machines and other appliances (www.nanotechproject.org).

Ironically, only a week before the Magic-Nano case broke, regulators, business executives and academics met in Berlin, Germany, to launch NanoCare, a public-private collaboration to investigate and prevent the adverse effects of nanomaterials on human health and the environment. The German Federal Ministry of Education and Research has committed €5 million, and industry will contribute another €2.6 million to the project over the next three years. Elsewhere, regulators in Europe and the USA are taking tentative steps towards figuring out how to control the new technology.

However, Chad Mirkin, Director of the Institute for Nanotechnology at Northwestern University (Evanston, IL, USA) and founder of various start-up companies, thinks that existing regulation is sufficient. "The bottom line is that

nanotechnology is a field, not a thing. We typically regulate things, matter, materials, pharmaceuticals, devices," he said. Regulation of the whole field would be not appropriate. "I won't call it silly, but it's not the correct approach to regulate nanotechnology. We should regulate the things that come out of nanotechnology." Mirkin also sees a need for common sense. "Everything that you make should be treated with respect until you understand its properties," he said. "If they're made out of bulk materials that are non-toxic, it's likely, but not absolutely correct, that the nanoscopic materials will be relatively non-toxic. If you start with really toxic materials and make nanoscopic versions of them, you should probably treat those with a lot more care."

Sean Murdock, Executive Director of the NanoBusiness Alliance (Skokie, IL, USA), an industry trade group, maintains that nanotechnology is already regulated. "It is subject

to FDA [Food and Drug Administration; Rockville, MD, USA], EPA [Environmental Protection Agency; Washington, DC, USA] and other regulations that are on the books right now," he said. "The question is really if existing regulations need to be modified, and, if so, how." As Philippe Martin, Principal Administrator of the European Commission's (EC) Directorate-General for Health and Consumer Protection, commented, "This is the billion dollar question."

However, it is not only environmentalist and consumerist interest groups that believe nanomaterials require special attention and regulation. In the summary document to its 2004 report, *Nanoscience and Nanotechnologies: Opportunities and Uncertainties*, the Royal Society and the Royal Academy of Engineering (both in London, UK) commented that "some regulations will need to be modified on a precautionary basis to reflect the fact that the toxicity of chemicals in the form of free nanoparticles and nanotubes cannot be predicted from their toxicity in a larger form and that in some cases they will be more toxic than the same mass of the same chemical in larger form" (The Royal Society & The Royal Academy of Engineering, 2004). The document goes on to recommend that releases of nanoparticles and nanotubes into the environment should be avoided as much as possible until more is known about their properties; that factories and research laboratories should treat nanomaterials "as if they were hazardous"; that nanomaterials should be treated as new substances under the existing European Union Notification on New Substances regulations; and that nano-ingredients in consumer products should undergo safety assessment.

"The regulators are running around in circles at the moment trying to resolve the issue," commented Anthony Seaton, Emeritus Professor of Environmental and Occupational Medicine at Aberdeen University, UK, who served on the Royal Society panel. "There are a lot of very difficult scientific questions involved in the

...others argue that nanomaterials are just scaled-down versions of bulk chemicals, or that nanomaterials should be considered on a case-by-case basis

whole issue of regulation, which I think haven't been solved. But more worryingly, they're not being approached in the research sense."

...policymakers and the public should keep in mind that people are routinely exposed to nano-sized particles with little damage

Various opinions abound: some in government and research feel that existing regulations and legislation are sufficient to deal with nanomaterials; others argue that nanomaterials are just scaled-down versions of bulk chemicals, or that nanomaterials should be considered on a case-by-case basis. The EC's advisory Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR) concluded that the current risk assessment procedures require modification (SCENIHR, 2006). "Even if we're not talking about changes in regulatory frameworks, we have to take great care not to assume that the methods that we've used for bulk substances work for nanoproducts," Martin said.

In the EU, these discussions coincide with the Registration, Evaluation and Authorisation of Chemicals (REACH), the proposed EU-wide law to regulate the use of most bulk chemicals. "Within the framework of that legislation, we have been discussing with the member states how to deal with nanomaterials, whether we should see them as new or existing substances, what to do with classification and labelling, and what are the needs in terms of test methods, risk assessment, and so forth," said Peter van der Zandt, an EC policy officer. However, REACH—proposed in 2003 before debates about the risks of nanotechnology became widespread—does not extend to nanomaterials produced in small quantities. "The registration triggers are uniform for all the chemicals. So if you have a nanomaterial that does not reach the tonnage trigger of one tonne per year, then apparently you wouldn't have to register it," van der Zandt said.

The UK Department for Environment, Food and Rural Affairs (DEFRA) has also taken steps to implement a voluntary stewardship programme as "a more formal conversation with industry, in which they

can provide us with information about any potential risks nanoparticles may pose," according to Chris Snary, DEFRA spokesman. The data will be evaluated for potential environmental and human health hazards by DEFRA's advisory committee on hazardous substances and government taskforces. Snary described the industry's response to voluntary reporting as "very enthusiastic": "Industry realizes that for them to maximize the potential benefits of nanotechnology in terms of the market and their activities there needs to be consumer confidence and so regulation or controls in this context and understanding potential risks are really fundamental."

The British plans and the new EU legislation are still in contrast to the situation in the USA. "REACH creates a much better system than what we have in place in the USA for chemical regulation, even with its possible holes and gaps," commented George Kimbrell, staff attorney for the International Center for Technology Assessment (CTA; Washington, DC, USA), a non-governmental organization dealing with the economics and ethics of technology. The Project on Emerging Nanotechnologies published a report, *Managing the Effects of Nanotechnology*, which calls on the US government to regulate nanomaterials (Davies, 2006). "Nanotechnology needs regulation and it's not going to get it under the existing system," said J. Clarence Davies, a political scientist and author of the report. Davies also authored the 1976 US Toxic Substances Control Act (TSCA), which enables the EPA to track industrial chemicals. "You could [regulate] by having specific legislation directed at nanotechnology. Or you could do it by adjusting existing legislation so it doesn't have the problems or defects or, in some cases, absolute vacuums that the current system has. It needs a lot of discussion to figure out whatever the best way is."

However, nanotechnology is emerging under a US leadership, which has been resistant to government interference and regulation. "The Administration is not exactly a pro-regulation and pro-health and -safety Administration. But it's important to talk about what needs to be done," Davies said. "It's not impossible to talk about new regulatory authorities or supplementing existing ones to make sure that the

technology is used, is applied and isn't stomped on or damned in the public arena by a not very well-informed public."

Davies argues that existing legislation, including the TSCA, are not up to the task. "The underlying assumption in the Act is that unless the EPA says something is wrong, the assumption is that it is okay: innocent until proven guilty," he said; however, the EPA stands by the TSCA. Enesta Jones, an EPA spokeswoman, said, "We believe that our existing authority for ensuring the safe use and handling of chemicals, the TSCA, applies to nanoscale materials and is adequate to regulate industrial nanoscale materials." Meanwhile, the EPA is planning to launch a voluntary stewardship programme in 2007 to complement the TSCA. Jones said the programme will assemble information from manufacturers and processors of nanoscale materials and will provide a foundation for future work and regulatory/policy decisions. "The value is in the information and experience that the EPA can get in terms of who is making nanomaterials and what kind of test data is available," Davies commented. "But it is an information-gathering device; it is not the answer to the regulatory problem."

...government must not ignore the fact that there are potential risks and hazards with all materials—nano or not—and should not create overly stringent regulations

The situation in the USA is further complicated by the fact that the FDA also holds regulatory power over nanomaterials. Unlike the situation in the EU, cosmetics—including sunscreens, which increasingly contain nano-sized particles—are considered medications and are therefore subject to FDA approval; however, the barriers are low. In 1999, the FDA ruled that nanoparticles from titanium oxide and zinc oxide in sunscreens were merely a reduction in ingredient size and did not constitute a new drug ingredient.

Environmental and other non-governmental organizations have taken a dim view of the FDA's position. In May, the CTA filed a petition with the FDA, urging the agency to address the human health and environmental risks of nanomaterials

in consumer products (International Center for Technology Assessment, 2006). The FDA, which declined to comment both on the petition and on the issue of additional regulation, has until November to reply. Kimbrell, who expects the issue to end up in federal court, said the FDA stance "flies in the face of the universal scientific assessment of engineered nanoparticles, which is that adverse effects of nanoparticles cannot be reliably predicted or derived from the known toxicity of the bulk material."

The first half of the petition urges the FDA to issue a formal opinion on nanoparticles and to enact regulation such as specific nanomaterial toxicity testing and mandatory labelling. The second half raises questions about whether nanoparticles in sunscreens might be inhaled or might penetrate the skin to enter the bloodstream. Kimbrell cites a number of crucial studies on the safety of nanoparticles, showing that they can produce DNA-damaging free radicals when exposed to ultraviolet light. The petition asks the FDA to declare that these products are "an imminent hazard to public health" and order manufacturers to cease production until "broader FDA nanotechnology regulations are developed and implemented" (International Center for Technology Assessment, 2006).

Ken Donaldson, a cardiovascular and lung toxicologist at the University of Edinburgh, UK, and an advisor to a wide range of groups on the toxicology of particles, said that policymakers and the public should keep in mind that people are routinely exposed to nano-sized particles with little damage. Although he is concerned about potential dangers from nanomaterials, he pointed out that "every time you go on a busy street, you're exposed in every breath to billions of nanoparticles," he said. "Most people go about their daily business and are not much affected by it."

Donaldson suspects that, eventually, some engineered nanoparticles might prove to be harmful—such as carbon nanotubes, which in some ways resemble asbestos. "The question is whether new nanoparticles are much more harmful than the ones that we know about. We need some toxicology to benchmark these [engineered nanoparticles] against existing particles," Donaldson said. "[I]t would be madness to try and call a halt [to nanotechnology]. [...]"

There is nothing that it has thrown up so far that would cause anyone to stop nanotechnology as an endeavour."

Murdock commented that government must not ignore the fact that there are potential risks and hazards with all materials—nano or not—and should not create overly stringent regulations. "There have been calls from activist groups for moratoriums on nanotech research and commercialization and production activity, but not from the government themselves," he said. "If we create incredibly tight regulations for any nanomaterials, we run the very real risk of people saying it's going to be cost prohibitive to commercialize those technologies and no longer trying to innovate in those areas. We have to be careful with the unintended consequences of being too restrictive or requiring too much burden of proof up front."

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doi:10.1038/sj.embor.7400799

Entente cordiale

Multiple symbiosis illustrates the intricate interconnectivity of nature

Life is war. Ever since living organisms arose on Earth, they have competed for resources such as space and food, as well as preying on each other. But amid all this feeding and being fed upon, many organisms peacefully cooperate to derive mutual benefit. Flowering plants feed pollinating insects with nectar and, in turn, depend on them for proliferation. Other plants harbour a microbial 'zoo', which provides them with nutrients from the soil or nitrogen from the atmosphere. Similarly, bacteria in the guts of plant-eating animals break down otherwise non-digestible compounds, such as fibre, as an additional source of nutrients for the host.

There are many well-studied symbioses of two organisms in which both participants benefit. But it is only recently that scientists have discovered more complex relationships involving three or more organisms from different taxonomic groups. Such multipartite symbioses are undoubtedly more common than the few examples discovered so far, and

are likely to embrace a huge range of organisms, according to Andreas Brune, Professor of Biogeochemistry at the Max Planck Institute for Terrestrial Microbiology in Marburg, Germany. "Multiple symbiosis is probably more widespread than we think, especially in view of the symbiotic systems involving different organizational levels, for example between bacterium, nematode and insect, or bacterium, protozoan and insect," he said.

The term symbiosis is defined as a close interaction between two or more species, which includes parasitic relationships in which the host organism derives no benefit at all. By contrast, a mutualistic symbiosis—sometimes called mutualism—is a long-term arrangement in which all partners derive a benefit. These might have evolved from parasitic relationships as the participants adapted to form a stable and mutually beneficial long-term relationship. When the partners are totally dependent on each other for survival, the relationship is