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Nanoparticles can penetrate brain tissue

Synthetic nanoparticles can penetrate tissue and cells, and spread throughout the body – even to the brain. Professor Peter Gehr of the University of Bern, an internationally renowned tissue specialist, is astonished that potential health risks are barely acknowledged outside the scientific world and government agencies.

Interview: Kaspar Meuli

Peter Gehr is Professor of Histology (the study of tissue) and Anatomy at the University of Bern. He is internationally renowned as a researcher, for example for his studies on the behaviour of nanoparticles in the lungs and on their interaction with cells. He is head of the national research programme NRP 64, which is examining the opportunities and risks of nanomaterials and will be initiated in December 2010.

environment: Is the Swiss population concerned about the effects of nanoparticles on human health?

Peter Gehr: No, people either have no idea about nanoparticles or do not regard them as a problem. The potential risks are also of little interest at the political level.

Why this lack of concern?

There is a great deal of fascination with nanotechnology and nanoparticles, and exciting new applica-tions have already been developed. For example, very tough and extremely light materials can be produced using carbon nanotubes. Bicycle frames, for instance, can now be made several kilograms lighter.

But there have also been alarming reports, for example about female Chinese workers suffering from severe lung damage due to high concentrations of nanoparticles at the workplace.

The study that reported this has in the meantime been found to have major shortcomings. When the media focused on this issue in December 2009, I thought this might result in a change of attitude. I believed that we nano researchers would now have to justify our actions because people would be worried and upset. But the press articles failed to trigger any notable discussions, and the subject was forgotten again within a few days. People are simply not reacting to the possibly harmful aspects of synthetic nanoparticles right now.

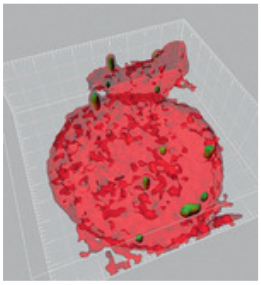
As a researcher, are you too reticent about your concerns?

No, on the contrary. I am constantly explaining the potential risks – in talks with politicians, in public lectures and in panel discussions. If nanoparticles are not solidly bound to another material, there is a risk that we could inhale them. They can then enter the bloodstream and spread throughout the entire body. As yet we do not know what the consequences of this are for our health. The mere fact that particles penetrate into the body is a problem, but this is barely acknowledged outside the realms of science and government agencies.

Presumably, people are also concerned about the contradictory assessments of the opportunities and risks of this technology.

I, too, became highly concerned about a year ago: tests on animals show that nanoparticles can pe-netrate tissue and cells, and spread via the bloodstream throughout the body – even to the brain. However, we do not yet know precisely how this happens. Researchers recently began addressing the phenomenon that nanoparticles which come into contact with our body become

coated with a protein layer. This occurs already when the particles come into contact with the surfacereactive film lining the interior of our lungs. We still know very little about this coating process. It is not clear how it actually occurs, whether the protein layer is altered upon penetrating the cell, and how it affects cell function. In my view, this is where the greatest uncertainty lies with respect to health risks associated with nano-particles.



Nanoparticles can penetrate into tissue and cells, and spread throughout the body via the bloodstream. This enlarged image of red blood cells, which was produced at the University of Bern, Institute of Anatomy, using a laser scanning microscope, shows green nanoparticles that have penetrated the cells. © Barbara Rothen-Rutishauser, Institut d'anatomie de l'Université de Berne

What is your opinion of studies that suggest that carbon nanotubes are as hazardous as asbes-tos?

It is well known that asbestos fibres can lead to cancerous changes to the outer layer of lung tissue. Tests have been carried out with animals using synthetic nanoparticles, i.e. carbon nanotubes of a size and structure similar to asbestos fibres. Experiments in the abdominal cavity of mice have re-vealed that, following the introduction of these particles, tumorous growths occurred that are regarded as precursors of cancer. By contrast, carbon nanotubes of a different form and size did not cause any such changes.

Is this result reassuring or are there grounds for concern?

I have fundamental concerns about carbon nanotubes, regardless of their form. The idea of having to breathe in nanometre or micrometre tubes is worrying. In fact, such scenarios are not so farfetched. At a recent nanotechnology congress in Japan, tyres were presented that were made more resistant thanks to carbon nanotubes. If all cars were to be fitted with such tyres, we would indeed have a problem, since rubber and the embodied nanoparticles are subject to abrasion and weathering, and are thus released into the air. And such a situation is by no means unrealistic.

The air we breathe is already polluted by particulate matter. Do these particles have a different effect on our health than industrially manufactured nanoparticles?

No – because the main problem of particles entering our body is their size. Size is much more impor-tant than the form or type of the material they are made from, as our research at the Institute of Anat-omy has been able to demonstrate. PM10 particles, which contain numerous nanoparticles, are sub-ject to the same physical mechanism when they are inhaled: upon deposition on the internal surface of the lung they become coated and are displaced by surface forces towards the lung tissue.

So particulate matter is just as hazardous as synthetic nanoparticles in this respect?

Yes, the effects are practically the same!

How problematic is it when nanoparticles are detected in the brain?

In my laboratory we were able to demonstrate with the aid of ultra-modern microscopes that nanopar-ticles can traverse the air-blood tissue barrier in the lungs. And similarly, they can pass the blood-brain barrier and penetrate into brain tissue, as colleagues have demonstrated in tests on animals based on radioactive substances. Although the quantities are extremely small, we are nonetheless talking about countless thousands of nanoparticles that reach the brain in this way.

Could this result in severe damage?

I am familiar with the work of a colleague who grew up in Mexico City and went on to work at leading centres for environmental research in the USA. She examined the brains of people who died from Alzheimer's disease, and compared these with the brain tissue of a young man who had lived all his life next to a busy road in Mexico City, and was killed in an accident. I will never forget how similar the images of these brains were. In both cases there were indications of the same inflammations of the brain – referred to as betaamyloid plaques – that are regarded as precursors of Alzheimer's disease. So theoretically one could conclude that air pollution causes Alzheimer's disease.

Has this been established?

No, it's still a hypothesis. But some researchers are now seriously asking themselves whether envi-ronmental pollution could be a cause of Alzheimer's. If this were the case, it would almost certainly be due to inhalation of particles that enter the bloodstream and cross the blood-brain barrier.

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