The impact of nanoparticles on our bodies| February 2025| N°190 | The Death of Death

Why desire the radical extension of life? Because everything valuable requires time. Time to write, to read, to create and refine work that leads us to deep meaning. Time to learn multiple languages, to peel back the endless layers of our identity, to reinvent the best version of ourselves. Time to love and be loved. Time to raise children, nurture grandchildren, and play with great-grandchildren — all part of the gradual unfolding of love. Yana D'Cortona, medical student, January 9, 2025.

Theme of the month: The impact of nanoparticles on our bodies.

The number of nanoparticles created directly or indirectly by humans is increasing overall, even if there are improvements in certain areas. Invisible to the naked eye (1-100 nanometers), these particles are omnipresent in our environment and infiltrate our bodies by various routes, including breathing, ingestion, or skin exposure. Their minute size enables them to pass through the respiratory tract, the digestive system, and other routes to cross biological barriers (air-blood, blood-brain, placental) and reach the brain, where they can potentially interact with our cells. These interactions, still poorly understood, raise an essential question: how do these tiny particles influence our health?

In general, it can, unfortunately, be said that many nanoparticles accelerate ageing or increase the likelihood of cancer. To date, fortunately, the benefits of medical progress continue to outweigh the effects of pollution, but disastrous medium- and long-term effects of nanomaterials (possibly combined in "toxic cocktails") cannot be ruled out.

How do nanoparticles enter our bodies?

Among the ways in which nanoparticles can be absorbed, we will study two main routes here:

1. Respiration: Inhalation of airborne nanoparticles. They can reach the lungs and brain.
2. Ingestion :
   Through food: Ingestion of particles contained in food and impact on the digestive system.
   By hydration: Consumption of water-containing nanoparticles promotes their absorption by vital organs.

Nanoparticles in the air: Inhalation and respiratory risks

Airborne nanoparticles come from industrial pollution, exhaust fumes, forest fires, and certain domestic activities. When inhaled, they can reach the lungs and enter the bloodstream.

These include: nanoparticles (Np) of titanium dioxide (TiO_2) used in paints and cosmetics (sunscreens) which, when generated in large quantities, can cause lung inflammation. The International Agency for Research on Cancer (IARC) has declared TiO2 NPs to be "possibly carcinogenic when inhaled", and highlighted the need to better understand their potential adverse effects via different routes of exposure in humans. Studies have shown that they can cross the placental barrier and reach fetal organs (liver, brain) in mice, causing developmental disorders and neuronal damage.

Nanoparticles resulting from the combustion of fossil fuels, notably soot and carbon black, are ubiquitous in our environment. The toxicity of soot particles stems from their physico-chemical characteristics. Soot particles penetrate deep into the respiratory tract, and are difficult to eliminate from the pulmonary alveoli. These fine particles penetrate deep into the respiratory tract, increasing the risk of asthma and cardiovascular disease. In 2013, IARC classified soot as a definite carcinogen (Group 1) in chimney sweepers, due to its association with skin and lung cancers.

Nanoparticles of heavy metals such as lead, mercury, and cadmium, present in industrial emissions, can also be found in the air. Heavy metals cannot be degraded or attacked by bacteria. The U.S. Environmental Protection Agency (USEPA) has classified mercury, cadmium, and lead as among the most toxic pollutants. Exposure to these heavy metals can cause neurotoxic effects, disrupting the nervous system.
Lead, for example, is recognized for its effectsmarked neurotoxic , affecting neurological development and neuronal transmission. Mercury, for its part, can cause serious neurological disorders such as Minamata disease. Oral exposure to high doses of cadmium can cause severe gastrointestinal irritation and significant effects on the kidneys. Chronic inhalation exposure has been associated with lung effects, including emphysema, and kidney damage. It can also cause bone damage.

A case study shows the impact of atmospheric nanoparticles on mortality in Canada: A study conducted between 2001 and 2016 in Canada revealed that prolonged exposure to atmospheric nanoparticles is associated with a significant increase in the risk of non-accidental mortality (+7.3%) and, more specifically, respiratory mortality (+17.4%). In Montreal and Toronto, this pollution is estimated to cause around 1,100 additional deaths per year. These results underline the urgent need to integrate nanoparticles into air quality regulation policies in order to limit their harmful effects on public health.

Nanoparticles in the food chain.

Heavy metals such as mercury (Hg), cadmium (Cd), lead (Pb), arsenic (As), and chromium (Cr) are present in the environment, due to industrial, agricultural, or urban activities. These activities lead to their incorporation into soils, water, and sediments, affecting living organisms including humans. At each trophic level, the concentration of metals increases. For example, a fish contaminated with mercury will be eaten by a predator, which will accumulate even more mercury in its body. This phenomenon is known as biomagnification.

Main food sources :

- Fish and seafood: Contamination by mercury, particularly methylmercury, which is neurotoxic. A recent study (2024) revealed that one in ten cans of tuna (a predatory species) exceeds the permitted mercury limit in Europe, exposing consumers to health risks.

- Vegetables and cereals: Absorption of heavy metals via polluted soils.
  In a study carried out in Canada in 2021, arsenic was detected in high concentrations (up to 2.20 ppm) in vegetable powders (92% of samples concerned). Leafy vegetables, such as kale, also showed higher levels of contamination than other vegetables, due to their high absorption capacity for soil particles.

- Meat and dairy products: Accumulation through ingestion of contaminated livestock feed.

Zinc oxide (ZnO) and copper oxide (CuO) nanoparticles used in agriculture are involved in the disruption of intestinal microbiota. By eating contaminated food, we absorb these particles, which can accumulate in our vital organs (liver, kidneys, brain), causing chronic poisoning, digestive disorders, and metabolic diseases.

Nanoparticles in water: Drinks and their impact on the body

Nanoparticles found in water come from industrial waste, microplastics, and chemicals. Nanoplastics (PE, PP, PET): present in tap and bottled water, now known to affect the hormonal system (Campanale et al., 2020). Silver nanoparticles (AgNPs): used for their antibacterial properties in certain filters and food packaging, can affect the intestinal microbiota. Heavy metal nanoparticles (lead, mercury, arsenic, cadmium): present in drinking water and certain contaminated water sources, can accumulate in our bodies and lead to neurological and renal risks (Khan et al., 2019).

Genotoxic effect of certain

Nanoparticles (NPs) of copper, zinc, silver, and quantum dots are attracting particular attention because of their potential genotoxic effects, mainly linked to the generation of reactive oxygen species (ROS), responsible for DNA damage. ZnNPs, commonly found in sunscreens and cosmetics, can release Zn^{2+} ions, inducing oxidative stress that alters DNA. In vitro studies have confirmed their genotoxicity, revealing DNA damage. Similarly, quantum dots, often composed of heavy metals such as cadmium (Cd) or selenium (Se), can release toxic ions capable of generating oxidative stress and causing genetic damage. Although nanoparticles may represent a health risk, they offer innovative solutions for combating cellular aging by targeting its key mechanisms.

Nanoparticle applications in medicine: Nanotechnology.

Nanoparticles have also been studied for their positive impact on health. They can repair DNA damage by delivering repair enzymes, as shown by gold nanoparticles that reduce age-related mutations. They also act against oxidative stress with antioxidant nanoparticles, such as those based on cerium dioxide (CeO_2), which protect cells from free radicals. In addition, nanoparticles can eliminate senescent cells by carrying senolytic drugs, such as quercetin, thus reducing inflammation and tissue damage. Finally, they help protect telomeres by delivering agents such as telomerase, extending cell lifespan. These applications position nanoparticles as promising tools for slowing or reversing cellular aging.

Conclusions and outlook:

Nanoparticles, because of their small size and ability to penetrate deep into our bodies, present both health risks and opportunities for therapeutic innovation. Their omnipresence in the environment and their presence in air, water, and the food chain underscore the importance of studying and understanding their long-term effects.

In this field, as in others, it is urgent and vital to :

- Make available data on nanoparticle densities in the human body and their known impact, whether negative or (unfortunately more rarely) positive.
- Reference any knowledge of negative (or, unfortunately, more rarely) positive "cocktail effects".
- Whenever possible, for new or increasingly used nanoparticles, organize longevity tests comparing the lifespan of mice (or other animals) with and without the substances concerned.
- Require companies developing nanomaterials to share data on the health effects of substances, particularly those for which they hold patents.

Alongside the study of nanoparticles, it is also crucial to examine the impact of microplastics, a category of plastic particles that are larger in size (< 5 mm), but still of concern due to their ubiquitous presence in our environment. Although their direct impact on human health is even less documented than that of nanoparticles, microplastics raise concerns due to their ability to transport toxic substances and accumulate in specific areas of the body, such as the digestive system and, even more seriously, the brain. This subject will be explored in greater detail in a future newsletter.

The bad news of the month: the United States and Health.

Among the tsunami of initiatives, President Trump's new US administration has made decisions that have, at least in the short term, effects generally considered negative for the health of Americans, of the world's population:

These include:

Withdrawal from the World Health Organization. Along with Liechtenstein, the USA will thus be the only United Nations member state not to be a member of the WHO. It should be remembered that:

- The WHO aims to enable citizens "to enjoy a state of complete physical, mental and social well-being, and not merely the absence of disease or infirmity."
  One of the consequences of the decision to leave will be to strengthen China's weight in this organization.
  The USA is the country with both the highest per capita health expenditure and the lowest life expectancy among countries with a high standard of living.

- The blocking of numerous health-related expenditures. So, a month after Donald Trump took office as the 47th President of the United States, almost all grant review meetings remain suspended at the National Institutes of Health (NIH), preventing the world's largest public funder of biomedical research from spending much of its $47 billion annual budget.

Find out more:

- *See in particular:* heales.org, sens.org, longevityalliance.org *and* longecity.org.
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