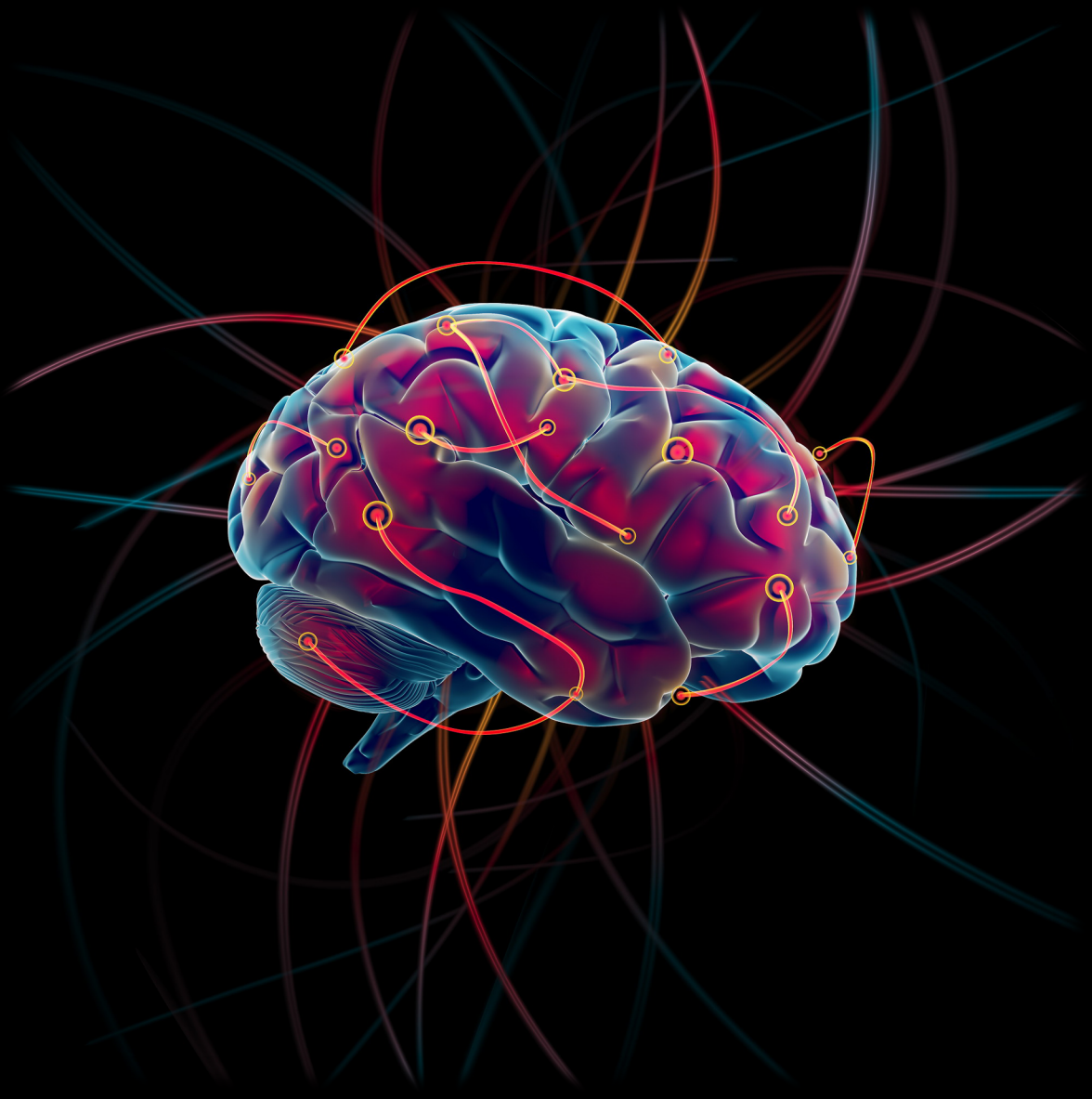
MICROPLASTICS CROSS THE BLOOD-BRAIN BARRIER



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Introduction

Recent mainstream media and internet articles have heralded a revolutionary new finding that plastic nanoparticles can cross the blood-brain barrier and are speculating that it is cause for deep concern. This is the scientific paper that has caused such a stir:

"Micro- and Nanoplastics Breach the Blood–Brain Barrier (BBB): Biomolecular Corona's Role Revealed"

V. Kopatz et al., Micro- and Nanoplastics Breach the Blood–Brain Barrier (BBB): Biomolecular Corona's Role Revealed, Nanomaterials, 13, 1404, 2023

Studies also show that people do not have a great deal of trust in the media, and would rather hear the science from scientists. As an independent expert, I have spent years checking such claims for the public. Let us examine this new story to determine what it really means and whether there is cause for panic.

Dust Dangers

"Nine out of 10 people breathe air that does not meet World Health Organization pollution limits. Air pollutants include gasses and particulate matter and collectively are responsible for ~8 million annual deaths. Particulate matter is the most dangerous form of air pollution, causing inflammatory and oxidative tissue damage."

J. T. Pryor et al., Frontiers in Public Health, Volume 10, Article 882569, 2022

This underscores the very real danger of air pollution and the harm that particulate matter can cause. The potential danger from particles cannot be dismissed, which means that this is certainly worth a closer look.

Particles in the Brain

That is a scary thought indeed. But it turns out that the movement of inhaled particles into organs, including the brain - so-called "translocation", has been known to scientists for decades.

The first studies showed movement of inhaled particles from the lungs to the liver but they were unable to detect any in the brain or other organs in that first study.

"These results demonstrate effective translocation of ultrafine elemental carbon particles to the liver by 1 d after inhalation exposure."

G. Oberdörster et al., Extrapulmonary translocation of ultrafine carbon particles following whole-body inhalation exposure of rats, J. Toxicol. Environ. Health A., Oct 25;65(20):1531-43, 2002

However, the following study by the same group did detect movement of particles into the brain.

"There was a significant and persistent increase in added 13 C in the olfactory bulb of 0.35 μg/g on day 1, which increased to 0.43 μg/g by day 7. Day 1 13 C concentrations of cerebrum and cerebellum were also significantly increased but the increase was inconsistent, significant only on one additional day of the postexposure period, possibly reflecting translocation across the blood–brain barrier in certain brain regions."

G. Oberdörster et al., Translocation of inhaled ultrafine particles to the brain, Inhalation Toxicology, 16:437–445, 2004

The Obertörster group continued to look into translocation of particles in the body. Here is a summary of research done at that time. They cited a study as far back as 2002, over two decades ago, showing that polystyrene was one such type of nanoparticle among several others. This shows that the "discovery" of synthetic polystyrene nanoparticles crossing into the brain of rodents is not new at all, but is, in fact, over 20 years old.

Table 4. Particle size and surface chemistry-related alveolar–capillary translocation.

Particle size (nm)	Type	Translocation	Localization/effect	Reference
5–20	Gold, albumin coated	Yes	Via caveolae	Mehta et al. 2004
8	Gold, albumin coated	Yes	Via "vesicles"	König et al. 1993
8	Gold, albumin coated	Yes	Via caveolae	Heckel et al. 2004
18	Iridium	Yes[a]	Extrapulmonary organs	Kreyling et al. 2002
30	Gold	Yes	Platelet?	Berry et al. 1977
35	Carbon	Yes	Liver	Oberdörster et al. 2002
60	Polystyrene[b]	Yes	Thrombus, early	Nemmar et al. 2002b Silva et al., in press
60	Polystyrene	?	No thrombus	Nemmar et al. 2002b
80	Iridium	Yes[a]	Extrapulmonary organs	Kreyling et al. 2002
240	Polystyrene, lecithin	Yes	Monocytes	Kato et al. 2003
240	Polystyrene, uncoated	No		Kato et al. 2003
400	Polystyrene	No	Thrombus, late	Nemmar et al. 2003

?, unknown.
[a]Minimal. [b]Indirect evidence.

G. Oberdörster et al., Nanotoxicology: An Emerging Discipline Evolving from Studies of Ultrafine Particles, Environmental Health Perspectives?, 113 (7), July 2005

The paper on synthetic polystyrene nanoparticles in hamsters was very informative. Nemmar et al. showed that the surface charge of the synthetic polystyrene particles determined their behaviour in the body. This is a key point because laboratory synthesized polystyrene particles of the type used in the new 2023 study are unlike the kind of polystyrene actually found in the environment.

A. Nemmar et al., Ultrafine Particles Affect Experimental Thrombosis in an *In Vivo* Hamster Model, Am. J. Respir. Crit. Care Med. Vol 166. pp 998–1004, 2002

This reinforces the point that studies on lab-made polystyrene are not relevant for understanding what actually happens in the environment. For that matter, scientists have also noted that polystyrene itself is the wrong type of plastic to use because the plastics in the environment are not polystyrene but polyethylene (PE), polypropylene (PP) and polyethylene terephthalate (PET).

K. Tanaka and H. Takada, Microplastic fragments and microbeads in digestive tracts of planktivorous fish from urban coastal waters, Scientific Reports 6(1):34351, 2016

In the table above, several types of nanoparticle were shown to translocate. What other materials have been found to move across into the brains of rodents?

Manganese Oxide Nanoparticles

"We conclude that the olfactory neuronal pathway is efficient for translocating inhaled Mn oxide as solid UFPs to the central nervous system and that this can result in inflamma- tory changes. We suggest that despite differences between human and rodent olfactory systems, this pathway is relevant in humans."

A. Elder et al., Translocation of Inhaled Ultrafine Manganese Oxide Particles to the Central Nervous System, Environmental Health Perspectives, 114 (8), 2006

Carbon Black Nanoparticles

"Higher levels of black carbon predicted decreased cognitive function across assessments of verbal and nonverbal intelligence and memory constructs."

S. F. Suglia et al., Association of Black Carbon with Cognition among Children in a Prospective Birth Cohort Study, Am J Epidemiol, 167, pp 280–286, 2008

Zinc Oxide Nanoparticles

"Our results suggest that acute exposure to ZnONP induces oxidative stress, microglia activation, and tau protein expression in the brain, leading to neurotoxicity."

H.C. Chuang et al., Acute Effects of Pulmonary Exposure to Zinc Oxide Nanoparticles on the Brain *in vivo*, Aerosol and Air Quality Research, 20: 1651–1664, 2020

Iron Soot Nanoparticles

"Our findings visually demonstrate that inhaled ultrafine iron-soot reached the brain via the olfactory nerves and was associated with indicators of neural inflammation."

L. E. Hopkins et al., Repeated Iron-Soot Exposure and Nose-to-Brain Transport of Inhaled Ultrafine Particles, Toxicol Pathol., 46 (1): pp 75–84, 2018

The list goes on and includes silver nanoparticles as well as titanium dioxide nanoparticles.

"…in the rat, spherical, small TiO_2-NPs significantly increased the BBB permeability and entered the brain. TiO_2-NPs were accumulated in the brain, but no obvious pathological anomaly was observed in the cerebral cortex and hippocampus."

X. Liu et al., Size- and shape-dependent effects of titanium dioxide nanoparticles on the permeabilization of the blood-brain barrier, Journal of Materials Chemistry B, 48, 2017

Some of these are more relevant than others. For example, we are actually exposed to soot, carbon black, zinc oxide and titanium dioxide because they are all present in the environment. However, we are never actually exposed to synthetic polystyrene nanoparticles of the kind used in the 2023 study.

While looking into the science on this topic, I was learned that the ability of nanoparticles to cross into the brain is exploited by scientists – they actually use particles as medicine to deliver drugs targeted to the brain. There are quite a few studies on the topic.

Concentration

Many of the studies shown above were performed with much higher concentrations of nanoparticle than found in the environment. By using high concentrations, the scientists are far more likely to see an effect, but using such high concentrations means that such studies are not valid for predicting what occurs in the real world, where actual concentrations are far lower. Biological effects and toxicity are very concentration dependent. For example, oxygen and table salt are considered safe and essential but both can be lethal if the concentration is increased. With that in mind, let us look at the concentration of polystyrene nanoparticle used in the new, 2023, study.

> *"The particles were delivered in an aqueous solution and were measured at a concentration of 0.5 mg/mL diluted in deionized water..."*

How much is that compared to the amount actually measured in the environment?

That amount translates to 0.5g per liter of water.

The amount in the environment is 1 ng per liter of water which means 0.000 000 001 grams per liter.

We now see that the amount of microplastic used in the 2023 study was about 100 million times too much compared to what is realistic, as described by Lenza et al..

R. Lenza, K. Endersa, and T. G. Nielsen, Proceedings of the National Academy of Sciences, 113(29), E4121 – E4122 . [201606615]. DOI: 10.1073/pnas.1606615113

This mis another reason why the 2023 study tells us nothing about what happens in the real world.

Perspective

As we have seen, particulate pollution is a real problem. It is appropriate to study it and evaluate the risks. However, it is not appropriate to obsess over plastics, which make up just 0.001% of particles we ingest.

Nur Hazimah and Mohamed Nor, Lifetime Accumulation of Microplastic in Children and Adults, Environ. Sci. Technol., 55 (8), 5084–5096, 2021

It is also not meaningful to scare the public over particles they will never encounter in the real world. Why scare the public with twenty year old news when we should be focusing on real and present dangers?

Conclusions

We have seen that what at first strikes us as a scary headline, turns out to be no more than just that. The "news" that nanoparticles can enter rodent brains is not news because it has been known and studied for over twenty years. Many kinds of particle including carbon, gold, silver, zinc oxide, titanium dioxide and manganese oxide were found to exhibit this ability.

So, the 2023 study was not actually news and it turns out that many types of nanoparticles behave in the same manner. So, why was there no media coverage for those other materials? Why only try to scare the public over plastic and ignore all the other materials? That is a recurring theme with the media. It is all too easy to get clicks and advertising dollars by needlessly frightening people.

Furthermore, the science done in the 2023 study was irrelevant because they used a kind of special synthetic nanoparticle that does not even exist in the environment. Not only that, but they used millions of times too high a concentration, further diminishing the validity of the work.

Should we be concerned then? Everyone has to choose for themselves what to worry about, but as a professional scientist, this does not make my top ten or even my top million.

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Short Biography

Chris DeArmitt PhD FIMMM FRSC CChem
President – Phantom Plastics LLC

Chris is considered one of the top plastic materials experts and problem-solvers in the world, which is why companies like HP, Apple, P&G, iRobot, Eaton, Total, and Disney come to him for help.

A deep understanding of materials combined with high creativity allows Chris to quickly solve even the toughest challenges. As one example, he solved a serious production issue that had plagued BASF for 30 years and cost them millions.

He has also received six open innovation cash prizes, placing him among the top 0.01% of innovators. In 2016, he published the book *Innovation Abyss* which reveals the true reasons for innovation failure and the proven path to success.

In 2018, Chris was featured on CBS's 60 Minutes with Scott Pelley as an expert witness in a class-action lawsuit related to Marlex mesh plastic implants. He helped thousands of women get settlements. Later television appearances include Sky News and the BBC as well as assorted radio and internet media interviews.

In 2020, Dr. DeArmitt published *The Plastics Paradox*, the first comprehensive, scientific overview of plastics materials and the environment covering all topics including waste, litter, microplastics, degradation, ocean plastics and more.
Chris has a multitude of granted patents as well as numerous articles, book chapters, encyclopedia chapters, and conference presentations to his name. He is an award-winning keynote speaker educating global audiences on plastic materials science and the environmental effects of plastics.

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