Nano-sized Plastics may Enter and Permeate Cell Membranes

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Researchers at the University of Eastern Finland have used molecular modelling methods to investigate the movement of nano-sized plastics in membrane structures. The results indicate that for some microplastics, passive transport through the cell membrane may be a significant gateway into the cell.

The occurrence of microplastics in nature has been studied extensively, also at the University of Eastern Finland. However, little is known about the health effects of microplastics, and understanding of their transport into the human body is also lacking. Any adverse health effects possibly associated with plastics may be caused by the plastic compound itself, or by the environmental toxins it carries. Many known fat-soluble environmental toxins and heavy metals are known to be able to adsorb on small plastic particles. This is why it is important to investigate the transport mechanisms of microplastics into the human body. However, research methods for the study of this transport are still lacking. Another key challenge in microplastics research is the lack of standardised methods.

With the help of molecular modelling, researchers at the University of Eastern Finland's School of Pharmacy analysed the behaviour and transport of nano-sized microplastics in bilayer membranes which mimic cell membranes. The researchers performed simple molecular dynamics simulations using well-known and widely used polyethylene (PE) and polyethylene terephthalate (PET) particles.

The cell membrane permeability of pulverised PE and PET plastics was also examined using the Parallel Artificial Membrane Permeability Assay method, PAMPA. The method is usually used to investigate passive absorption of medicines, but it hasn't been used to study microplastics before. The PAMPA method was used to investigate the amount of matter permeating the membrane. The amount of plastic permeating the artificial membrane was measured by NMR spectroscopy at certain intervals.

In both PE and PET experiments, the movement of molecules was controlled only by concentration differences on different sides of the membrane, and by occasional movement induced by heat. In other words, the methods provided information on the passive permeation of molecules through the membranes.

In the computer simulations, PE particles were found to prefer the centre of the lipid membrane as their location. In the PAMPA experiments, PE plastic partially permeated the membrane, but membrane permeability slowed down significantly over time, probably due to the accumulation of plastic in the membrane. In the simulations, the preferred location of PET particles was, to a certain degree, the surface part of the membrane, and in the experiments, they permeated the membrane fairly well. According to this study, the properties of the membrane structures were not significantly affected by individual plastics.

The study used molecular modelling of membrane structures and the PAMPA method to study the membrane permeability of microplastics. In the image on the left, the preferred location of PET plastic in the simulation is on the surface parts of the membrane. In the image on the right, the PAMPA method was used to study the movement of plastic across a membrane between two chambers.

The study provides a starting point for the further development of computer simulations and experimental methods for the needs of microplastics research. Significantly more information is still needed on the active transport of microplastics, such as their binding to transporter proteins, possible phagocytosis, and toxic effects on cells.

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