Faculty and Researcher Directory
Philip Demokritou

Associate Professor of Aerosol Physics

Department of Environmental Health

Dr. Demokritou's research interests are primarily in the areas of aerosol science and technology with emphasis on the elucidation of particulate matter (PM) health effects and environmental health and safety implications of engineered nanomaterials (ENMs). His particle research has involved the development of personal PM monitoring systems for use in exposure assessment and epidemiological studies and methods for the physico-chemical and in-vitro/in-vivo toxicological characterization of particles. Such novel methods linking particle exposures to toxicology and adverse health effects have been widely used by scientists in the field and also adopted as reference methods by scientists at US EPA, Environment Canada, and other PM exposure assessors around the world, and have helped to advance the field of particle health effects. His current research focuses on nanosafety and nano-bio interactions and the role of ENM structure on bioactivity. His nanosafety research has involved development of in-vitro screening approaches for nano-specific effects (DNA damage, epigenetics, translocation of ENMs across biological barriers, etc), "safer-by-design" approaches for families of ENMs such as metal and metal oxides, development of advanced tools and framework approaches for in-vitro/in-vivo dosimetry, linking exposures from nanoparticles released across life cycle of nano-enabled products (NEPs) to toxicology and adverse health effects, and environmental nanotechnology applications for pathogen inactivation. Dr. Demokritou is currently the Director of the Center of Nanotechnology and Nanotoxicology at Harvard University (www.hsph.harvard.edu/nano). He served as a co-PI of the Harvard-EPA PM Health Effect Center (1999-2010, US EPA star grant) and as the Director of the Harvard-Cyprus International Institute for the Environment and Public Health from 2005-2008 and participated in the development of graduate level degree programs in the area of Environmental Health. He served as PI, co-PI, or co-investigator on several grants funded by NIH, EPA, NIOSH, NSF, USDA/NIFA, CPSC, and EU research framework (FP7). He holds 8 international/US patents and inventions licensed by Harvard to various companies in the fields of air pollution and nano-biology. He is a co-author of two books, numerous book chapters, and hundreds of articles in leading journals and conference proceedings in the particle health effect and aerosol engineering fields. Dr. Demokritou's innovative research was highlighted in major mainstream media and online magazines including articles published in the Economist, NanoWerk, Chemistry World, The Scientist, ACS C&En News, MIT News, Harvard Gazette, and NPR news. Dr. Demokritou is currently an Associate Professor at Harvard School of Public and Editor-in-Chief of NanoImpact, a journal that focuses on all aspects of nanosafety research (Elsevier).

The Center for Nanotechnology and Nanotoxicology at the Harvard School of Public Health

Dr. Demokritou is currently the Director of the Center for Nanotechnology and Nanotoxicology at the Harvard T. H. Chan School of Public Health. The center draws on decades of experience with environmental pollutants and the health effects of particles to address the unique environmental health and safety (EHS) concerns raised by engineered nanomaterials (ENM) & nanotechnology applications.

The center's mission is to integrate exposure science and nanotoxicology risk assessment to facilitate science-based decision-making regarding nano-EHS. In doing so, the center brings together stakeholders including industry, academia, policy makers, and the general public to maximize innovation and growth and minimize environmental and public health risks.

Why Nano?

Nanoparticles are integral to an increasing array of products, from sunscreen and cancer drugs to batteries and semiconductors. However, the rapid expansion of this technology raises safety concerns and calls for a better understanding of how nanomaterials affect biological and environmental systems. Specifically, we need to learn more about the bio-nano interactions at cellular/molecular, organismal, and environmental levels. Since nanoparticles often display unexpected biological properties, we need to discover new toxicologic priciples to understand their potential risks. This assessment is complicated by the fact that nanoparticles are able to penetrate tissues more deeply than larger particles, so careful evaluation of the dose and especially the anatomic distribution of nanoparticles is essential. It is also important to examine species differences and differences between in vitro versus in vivo exposure. It is clearly imperative that the fields of nanotoxicology and risk assessment keep pace with nanotechnology and its expanding universe of applications.

New Technology Brings New Questions

How do we balance the potential of nanotechnology with the potential hazards from new and often inadequately characterized materials? The rapid expansion of nanotechnology is a powerful scientific and economic force. However, we need to match this progress with careful evaluation of the possible toxicity of nanomaterials and technologies. This process can be made more efficient by searching for fundamental principles that govern biological responses to nanomaterials, rather than assessing the toxicity of specific nanomaterials one at a time.

How do we discover the rules of nanotoxicology? A promising approach is to examine families of engineered and rigorously characterized particles and to study the role of such factors as particle size and shape, composition, and charge. Our NanoCenter is generating these rational families of particles, holding some parameters constant while changing others systematically. We bring together modern in vivo and in vitro toxicologic approaches to carry out the biologic evaluation of nanomaterials. We also seek to advance methods needed to evaluate the safety of nanotechnology.

The NanoCenter combines excellence in material and exposure science with demonstrated skills in lung toxicology, pharmacokinetics, and biology. By developing and utilizing industrially relevant ENM generation systems that enable us to control the properties of "real world" nanomaterial exposures, we will better understand how particle dynamics and physical and chemical parameters alter both pharmacokinetics and the extent of possible injury. Correlations will be made between in vivo and in vitro methods, as well as between in vitro systems using rodent versus human cells. We will also study safer nanomaterial formulation concepts which can reduce the environmental and health implications of ENMs.

The NanoCenter will also develop and deploy a variety of exposure assessment technologies to define human exposures to nanomaterials during their full life cycle (manufacture, use, and disposal). Using methods of lifecycle analysis (LCA), we will assess exposures to nanomaterials from "cradle to grave." Finally, all these data will be integrated using methods of risk assessment and physiologically based pharmacokinetic models. The end result will be a science-based guide to appropriate standards for safety. We neither want to create human health hazards nor do we want to erect unreasonable barriers to the creative uses of nanomaterials in industry and medicine.

Laboratory for Environmental Health Nanoscience (LEHNS)

Dr Demokritou is currently the Director of the LEHNS lab. LEHNS research focuses on the implications and applications of engineered nanomaterials (ENMs) and nanotechnology. The lab's approach is to examine families of engineered and rigorously characterized ENMs and study the role of such factors as particle size, composition, charge, and their bio-interactions. Recently, the lab has been conducting research on the interactions of industry-relevant ENMs with physiologic fluids. We bring together contemporary in vivo and in vitro toxicology as well as material and aerosol science approaches to assess nano-bio interactions and carry out the biologic evaluation of ENMs.

The LEHNS Laboratory is fully equipped with systems for the generation of artificial monodisperse and polydisperse particles, as well as state of the art instrumentation for the real-time measurement of the physico-chemical properties of particles from 2 nm to 20 microns. Other activities of the laboratory include the design of particle-classification techniques such as impactors and speciation samplers and, performance evaluation of air sampling techniques. More than a dozen instruments and methods including a number of US patented methods have been developed over the years, for the physico-chemical, and biological characterization of particles. These novel techniques have been used extensively by air pollution scientists and human exposure assessors in United States and worldwide.

News from the School

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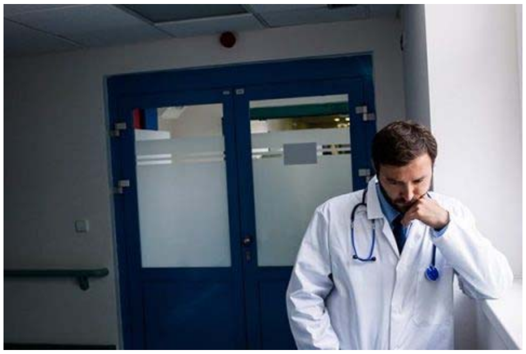
Save lives, save the planet



Physician burnout a 'public health crisis'