Plankton and turbulence

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Although we now know that microorganisms rule the oceans - controlling productivity and biogeochemical cycles - we largely ignore how they are affected by typical fluid flow conditions. For example, microbes are routinely exposed to turbulence, yet physicists have ignored microbes and biologists have ignored turbulence. Here I present microfluidic and millifluidic experiments, combined with mathematical models, to show that fluid flow can have profound effects on the biomechanics and the ecology of swimming microorganisms. I illustrate this through a series of examples, and will focus in particular on gravitaxis, the tendency of many phytoplankton species to swim along the direction of gravity. I will show that, in the presence of flow, gravitaxis results in intense clustering of cells in layers and patches, akin to those often observed by oceanographers, which can have profound effects on plankton population dynamics. Intriguingly, plankton seem to 'know their fluid mechanics', as I will demonstrate through recent evidence that these minute organisms are able to actively evade turbulence by sensing the simplest among the cues inherent in small-scale turbulent eddies. In addition to representing a new class of active particle problems that promises to keep the fluid mechanician busy for some time to come, these processes are environmentally important because they affect the ecological dynamics and biogeochemical consequences of some of the most important players in aquatic ecosystems.

Short biography:

- PhD, University of Padova, Italy, 2002.
- Postdoctoral Fellow, Department of Mathematics, MIT, 2002-2005.
- Assistant Professor, Department of Civil and Environmental Engineering, MIT, 2005-2009.
- Associate Professor, Department of Civil and Environmental Engineering, MIT 2009-2012.
- Associate Professor with Tenure, Department of Civil and Environmental Engineering, MIT, 2012-2015.
- Professor Department of Civil, Environmental and Geomatic Engineering, ETH Zürich, Switzerland, 2015 to date.

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