Unraveling the microscale mechanisms driving particle degradation in the ocean

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The sinking of organic particles to the ocean depths is the main driving force of the biological pump, the process responsible for the export of more than 50 Gt of fixed CO_2 annually and one of the major fluxes in the oceans' carbon cycle. Yet, the mechanisms determining the magnitude of the pump remain poorly understood, limiting our ability to predict this carbon flux in future ocean scenarios. Current ocean models assume that the biological pump is governed by the competition between sinking speed and degradation rate, with the two processes independent from one another. In this talk, I will demonstrate that contrary to this paradigm, sinking itself is a primary determinant of the rate at which bacteria enzymatically degrade particles in the ocean. By combining video microscopy and microfluidic experiments to directly observe and quantify bacterial degradation of individual organic particles in flow, I will show that even modest sinking speeds of 8 meters per day enhance degradation rates more than 10-fold. I will further discuss the molecular mechanism behind the sinking-enhanced degradation, as well as possible ways by which bacteria can slow the sinking of particles. Finally, using the results obtained from a mathematical model, I will show that the flow associated with sinking is a major contributor to the observed magnitude of the vertical carbon flux in the ocean, and will outline major open questions in the field.