Miller Institute Newsletter

Miller Fellow Focus:
Rachel Pepper

Winter
2013

Life on earth is dominated by microscopic organisms, too small to see with the naked eye. These include tiny bacteria, complicated unicellular organisms, and multi-cellular organisms, including the juvenile form of animals we are familiar with such as starfish and barnacles. Many of these microscopic organisms live in water – either in freshwater, the ocean, or inside other organisms like humans. Thus, their survival is dependent on their manipulation of fluid flow. How do tiny organisms like this interact with the fluid around them to do the things they need to do to survive?

Since these organisms are so small, the speeds at which they move and the forces they generate are also small. This means they live in a regime of fluid flow very different from what humans experience – for tiny organisms, viscosity is much more important than inertia. Unlike a person, if a bacteria stops swimming, it stops moving immediately and doesn't coast through the water at all.

Miller Fellow, Rachel Pepper is exploring the question of how tiny organisms interact with fluid flow with two projects: one involves microscopic organisms that generate fluid flow to survive, and the other involves how tiny organisms navigate in complicated ocean flows.

Fluid Flow Generated by Microscopic Organisms:

Rachel and her colleagues, including former Miller Fellow Marcus Roper, study a class of microscopic organisms called sessile suspensions feeders. Most of these microscopic suspension feeders are single-celled, and are a few to a few hundreds microns large. They live attached to surfaces (such as rocks, leaves, and even aquatic animals) and eat debris and bacteria. Since they live attached to surfaces, they can't swim to find food. Instead, they generate a flow in the fluid around them that brings their food to them. Sessile suspension feeders are ubiquitous in bodies of water ranging from mud puddles to the ocean and perform a vital role in keeping these bodies of water clean by consuming bacteria and debris. It has been estimated that when food is abundant, the tiny suspension feeders in the ocean may become so plentiful that they filter up to 100% of the ocean for food each day.

Since these organisms are so effective at cleaning bodies of water, they can also play a critical role in cleaning up after man-made disasters such as sewage leaks and oil spills. However, to really understand their ability to clean the water, and their role in the food chain, we need to understand the filter feeding currents that they generate. An understanding of the flow generated by filter feeders may enable not only a better understanding of marine ecology and carbon cycling, but also improved water treatment plant design.

The feeding flow that has been measured for these organisms in the past is a torroidal eddy (see Figure 1), which

INSIDE THIS EDITION

Miller Fellow Focus	1-2
Gifts to the Institute	3
To Note	3
Professorship Awards	4

means that the flow recirculates, bringing the same bit of fluid past the organism repeatedly (even after the organism has consumed all the useful nutrients from the fluid). Rachel has investigated how eddies form in the feeding current around suspension feeders and if there are any feeding strategies the organisms can employ to avoid eddies and access more nutrients. She and her colleagues have measured the flow created by these organisms under the microscope and compared this flow to calculations and simulations to show that the eddies are caused by the organism forcing fluid near surfaces – either the surface they are attached to, or the slide and the coverglass they are observed between in most experiments.

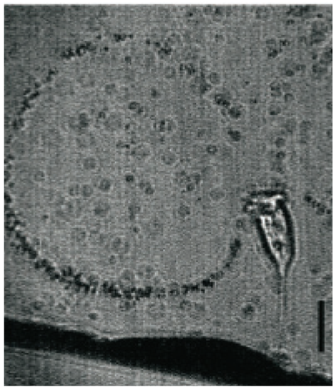

Figure 1. A single Vorticella observed under the microscope. Small beads follow the flow and highlight the eddy in the feeding current. The scale bar is 50 microns.

Rachel and her colleagues have shown that without the slide and coverglass, sessile suspension feeders generate eddies that are much bigger and slower than the ones observed under the microscope, so that organisms have better access to nutrients and filter more water than some had previously thought. They have also found some simple solutions the microorganisms employ to eliminate the recirculating eddies and improving access to nutrients. In the future, Rachel plans to measure the behavior of and the fluid flow around sessile suspension feeders without a slide and cover glass distorting the flow. She will use this information combined with simulations of nutrient uptake to determine if organisms in nature are behaving in a way that optimizes the feeding current they generate.

Microscopic Organisms in Ocean flows:

The ocean is filled with microscopic organisms that need to navigate in order to survive. Predators need to find patches of prey, prey need to avoid predators, and both need to find mates in order to reproduce. However, these organisms are very small compared to the scale of the flow in the ocean, and can swim only very slowly compared to the typical speed of ocean flow. How do such tiny organisms get where they need to go in complicated ocean flow? This is a question Rachel hopes to answer with the help of her Miller hosts, Mimi Koehl, Mark Stacey, and Evan Variano. Rachel is particularly interested in whether tiny organisms navigating in the ocean can use hydrodynamic cues from how the fluid flow around them feels in order to help them navigate.

To answer this question, Rachel is using marine larvae as a model system. Marine larvae are the juvenile form of many common marine animals, such as starfish, barnacles, and the coral in a coral reef. As part of their life cycle, these organisms release many microscopic larvae (typically 100-500 microns in size) into the ocean. The larvae are tumbled around by the ocean flow and eventually need to settle back down onto an appropriate place in order to grow into an adult. If the larvae can't find good places to settle, the species won't survive. Since species survival is at stake, marine larvae are a particularly good system for studying navigation in the ocean.

Rachel and her hosts are measuring how the water moves above rough biological surfaces, such as coral reefs, that would be good environments for larvae to colonize, and determining from these measurements what forces larvae would feel in such fluid environments. They are also using microfluidic devices to generate controlled flow that mimics the flow in the ocean. Using these devices, the response of living larvae of various species can be observed under the microscope to determine if the larvae respond to the forces that they would feel in the ocean. Rachel anticipates that the results of these two sets of experiments will help determine if (and how) larvae use cues from the flow around them to navigate in the ocean.

Rachel is interested in physics education research and spent the two years pre-Berkeley studying how upper-division physics courses can be changed to improve student learning. When not exploring fluid mechanics or teaching physics, Rachel enjoys baking, running, hiking, and skiing.

Gifts to the Miller Institute

The Miller Institute gratefully acknowledges the following contributors to the Miller Institute programs in 2012. These generous donations help support the Miller Fellowship program as well as the general programs of the Institute. In 2011, the Judith K. and Gabor A. Somorjai endowment was established and we are happy to acknowledge additional gifts made to the Institute in support of this fund.

Platinum Circle ($10,000 - $24,999)
Robert G. Bergman's Gerald E. K. Branch Distinguished Professor Fund

Gold Circle ($2,500 - $9,999)
William Craig

Director's Circle ($1,000 - $2,499)
Jasper Rine
Randy Schekman & Nancy Walls
Anthony Walsby & Fausta Segre Walsby

Miller Partners ($500 - $999)
Robert & Wendy Bergman
Craig Evans & Claudia Deering
Eliot Quataert
Christina Shannon
Terence & Freda Speed
Peter & Gloria Yu

Miller Associates ($250- $499)
Rachel Akeson
Lutz Duemgen
Montonori Hoshi
Ronald Johnson
Stephen Leone & Mary Gilles
Erick & Janet Matsen
Dustin & Kate Rubenstein
Rich Saykally & Chris Read
Jason Stajich

Miller Advocates (up to $249)
Anonymous (1)
John & Diane Bercaw
Roger & Elizabeth Blandford
Steven & Diana Brenner
Dmitry & Olga Budker
William Clemmens
Kathryn Day
Alexei Filippenko (in memory of Wallace L.W. Sargent)
Carole Hickman
Ronald Hoy & Margaret Nelson
John Hunter & Amy Roussel
Yasuyuki Kawahigashi
Takahiro Kawai
Judith Klinman
Mimi Koehl
Anthony & Mary Mahowald
Christopher McKee
Nancy Missert
Martin Scharlemann & Barbara Wagner
John & Delia Taylor
Jesse Thaler
Dan-Virgil Voiculescu
Kenneth Wachter

Somorjai Endowment
Lawrence Dubois
Kam-Bui & Po-Ling Luk
John Simons

Awards and Honors

Sandra Faber (VMP Spring 2005) has been awarded the National Medal of Science by President Obama, the U.S. government's highest honor for a scientist.

Richard Saykally (MP 1985-86, 1997-98, Fall '06) was awarded the Faraday Lectureship Medal at the Royal Society of Chemistry in Birmingham, U.K.

Bernard Sadoulet (MP Spring 2011) was awarded the 2013 W.K. H. Panofsky Prize in Experimental Particle Physics for his pioneering work in the development and use of phonon detection techniques enabling direct searches for interating massive particles.

Hermona Soreq (VMP Spring 2009) has been awarded one of the European Research Council's Advanced Awards for 2012.

Alice Guionnet (VMP Fall 2006) and Eliot Quataert (MP 2009-10) were each awarded $500,000 open ended grants from the Simons Foundation to further their independent research.

Birth Announcements

Rebecca Schulman (MF 2008-11) and Marc Kamionkowski (VMP Fall 2010) announce the birth of their son, Isaac Nathan Kamionkowski, born July 20, 2012.

Genevieve Graves (MF 2009 - 12) and her husband, Alex Lamb, announce the arrival of their son, Thorfinn Eric Lyman Lamb, born August 24, 2012.

Jesse Thaler (MF 2006-09) and his wife, Sasha Diaz, announce the birth of Adrian Diaz Thaler born November 22.

Alice Shapley (MF 2003-05) and her husband, Edwin Schauble, announce the birth of their daughter, Anna Rose Schauble born November 30, 2012.

Miller Institute News
Winter 2013
2536 Channing Way, #5190
Berkeley, CA 94720-5190
Phone (510) 642-4088
Fax (510) 643-7393
http://millerinstitute.berkeley.edu

Please send address corrections to:
miller_adm@berkeley.edu

1-36299-24810-44

Non-Profit
Organization
U.S. Postage
PAID
University of
California

Professorship Awards Announced

The Miller Institute is pleased to announce the awards for Miller Research Professorship and Visiting Miller Professorship terms in the 2013-14 Academic Year. The following outstanding scientists will devote 100% of their efforts to research, pursing promising leads as they develop. We congratulate and welcome these new Miller Institute members.

Miller Professors

Roland Bürgmann, Earth & Planetary Science

Eugene Chiang, Astronomy

Ehud Isacoff, Molecular & Cell Biology

Mimi Koehl, Integrative Biology

Dean Toste, Chemistry

Visiting Miller Professors

Douglas Black, Molecular & Cell Biology
Roger Blandford, Astronomy
Craig Carter, Materials Science & Engineering
Juan Ignacio Cirac, EECS
Ron Folman, Physics
Aditi Lahiri, Linguistics
Charles Langley, Integrative Biology
Somorjai VMP - Angelos Michaelides, Chemistry
Joachim Sauer, Chemistry
Scott Tremaine, Astronomy
Chandra Varma, Physics

The Miller Institute is "dedicated to the encouragement of creative thought and the conduct of research and investigation in the field of pure science and investigation in the field of applied science in so far as such research and investigation are deemed by the Advisory Board to offer a promising approach to fundamental problems."