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Mathematics+Biology=Possible Cancer Cure

by Steven K. Wagner
Photo by Kevin Mapp

INNOVATOR: Lisette de Pillis

With any basic research, two heads are better than one. Lisette G. de Pillis, professor of mathematics, subscribes to that notion, and often involves students in her research.

Put simply, she finds that students bring a fresh approach and new questions to the table.

“HMC students have solid scientific training through the common core coursework they all take,” de Pillis said. “As a result, they’re able to tackle challenging interdisciplinary problems, and they sometimes ask questions that may not occur to a professional.”

That’s important when math and biology converge, as they do with de Pillis. She holds the Norman F. Sprague Chair of Life Sciences, is co-director of the Center for Quantitative Life Sciences, is an investigator on two National Science Foundation-funded mathematical biology projects, and advises for the college’s Mathematical Biology major, one of the first such undergraduate programs in the United States. The mathematical biology program, the only one that meets the Bio2010 recommendations for preparing research scientists in the 21st century, has risen to become a leader in both curriculum and undergraduate research innovation.

De Pillis joined HMC in 1993, but her interest in math and biology dates back further. As a young girl, de Pillis, inspired by her own female pediatrician, wanted to become a medical doctor. Although her undergraduate degree is in mathematics and computer science, her continuing interest in medicine is interwoven throughout her mathematical biology work.

Mathematical biology is the science of solving biological problems using a range of mathematical tools. De Pillis’ ongoing research — curing cancer with mathematics — involves the use of mathematical models to address the complex interactions of growing tumors with the body’s immune system to better treat, and perhaps someday cure, cancer. De Pillis uses differential equations—mathematical sentences — to define the variables involved in tumor growth rates, to identify the effects of different concentrations of immune cells and drugs on tumors, and to anticipate the tumor decay patterns.

One aspect of that research involves the evaluation of two important immune cell types: the more generalized natural killer cells, and T-cells, which are specific to a disease. Using existing data, De Pillis and her team created several models based upon differential equations, making predictions about immune cell response.

“We focus mainly on deterministic modeling, but some of our models have probabilistic elements,” she said. “What we do is very different from statistical analysis on large amounts of data, which may involve evaluating the response of some cohort, for instance, to interferon gamma.”
De Pillis also is using optimal control theory, a mathematical strategy for determining best approaches to administering medication to cancer patients. Objectives include minimizing chemotherapy side-effects and immune system damage while maximizing tumor destruction to find an intersection resulting in an optimal therapy regimen.

“The best way to motivate students to learn new science is to have them work on a problem that must be solved,” she said.

Ben Preskill, a senior mathematics major, said working with de Pillis had a profound effect on him and influenced his decision to apply to medical school.

“It really shaped my career goal and what I want to do with my education, shifting me very much toward applying math to tangible human problems,” he said.

It all comes down to teamwork—and creating future scientists.

“I have a real passion for strengthening the ties between mathematics and the sciences,” de Pillis said. “Will we cure cancer? Perhaps not. Are we training students to speak the multiple scientific languages without being afraid to work across disciplines? Most definitely.”

HMC

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