UC San Diego Undergraduate's Research Makes New York Times Top Science Stories of 2007

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Sherry Seethaler

Dorian Raymer *Credit: Kim McDonald, UCSD*

A southern Californian at heart, Dorian Raymer surfs, skateboards and fishes for yellowtail. But he also enjoys dabbling in different academic disciplines. He brought together three of his academic pursuits-mathematics, physics and computer programming-in a study he initiated while an undergraduate physics major at UC San Diego that was named one of the top science stories of the year.

This week the *New York Times Magazine* named the study on knot formation by Raymer and Douglas Smith, an assistant professor of physics at UCSD, one of the Top Science Stories of 2007 in its annual "Year in Ideas" issue. The editors of the Sunday *New York Times Magazine* chose the stories from a pool of nominees submitted by *New York Times* reporters.

Since their paper was published in the *Proceedings of the National Academy of Sciences* in October, the two physicists' work has captured headlines in daily newspapers and magazines around the world, as well as more technical publications such as *Popular Science, Science News, New Scientist* and *Physics Today.* A feature on their research will appear in the February issue of *Discover Magazine*.

"It was fun to talk to the reporters from many publications, as far away as Sweden, who contacted us about the story," said Raymer. "But we were most happy about the response of the mathematicians. We were using mathematical concepts that can take years to fully understand, so we weren't sure how our research would be received. However, Andrew Belmonte, a math professor at Penn State University, published a favorable commentary on our paper in the following issue of PNAS. He concluded that the study of physical knots has now come into its own as an experimental science and that the mathematical model we proposed is likely to have interesting implications."

"Many undergraduate students have worked in my lab over the years, but this is the first time one of my students initiated a project that has generated so much interest from the press," said Smith. "It is a great lesson for students that the most important thing in science is to be curious and creative."

Digital photos of knots with computer-generated drawings based on mathematical calculations. *Credit: Dorian Raymer, UCSD*

In recognition of the importance of providing undergraduate students with research experience, this year UCSD launched the Regents Scholars program. The program guarantees experience in a research laboratory for top entering freshmen. "In the Division of Physical Sciences, we have a high faculty to student ratio that makes it possible for many of our undergraduate students to get involved in research," said Mark Thiemens, dean of UCSD's Division of Physical Sciences. "Many of our alumni, whether they have gone into industry or academia, tell us that gaining research experience as undergraduates was the single most important part of their education."

Raymer and Smith's study investigated the likelihood of knot formation and the types of knots formed in a tumbled string.

"We began the study because I was curious about knot theory in mathematics, and we wondered whether it might be applicable in a physics experiment," said Raymer.

"When we started looking into this, it soon became clear that very little experimental work had been done to apply knot theory to the analysis and classification of real, physical knots and there was little understanding of how knots form," said Smith. "But knot formation is important in many fields. For example, knots often form in DNA, which is a long string-like molecule. Certain anti-cancer drugs stop tumor cells from dividing by blocking the unknotting of DNA."

Raymer and Smith designed a simple experimental set up consisting of a plastic box spun by a computer-controlled motor. A piece of string was dropped into the box and tumbled around like clothes in a dryer. Knots formed very quickly, within 10 seconds. The researchers repeated the experiment more than 3,000 times varying the length and stiffness of string, box size and speed of rotation. The result was a lot of tangles to be classified.

Dorian Raymer

Image credits: Kim McDonald and Dorian Raymer, UCSD

"It is virtually impossible to distinguish different knots just by looking at them," said Raymer. "So I developed a computer program to do it."

The program translated the crossings of the string into a mathematical fingerprint for each knot. It used the Jones polynomial-a famous math formula developed by Vaughn Jones, a mathematics professor at UC Berkeley-which automatically simplifies knots that are identical, but look different.

Raymer and Smith developed a basic model for knot formation. String forms concentric coils, like a looped garden hose, due to its stiffness and the confinement of the box. The free end of the string weaves through the coils, with a 50 percent probability of going under or over any coil. The computer simulation that they developed based on this model mimicked the experimental results.

Raymer is currently a research assistant working with Smith and is thinking about graduate school. He is still deciding between his love of physics, mathematics, neuroscience and computer programming, and keeping his eye out for a new project that will bring them all together.

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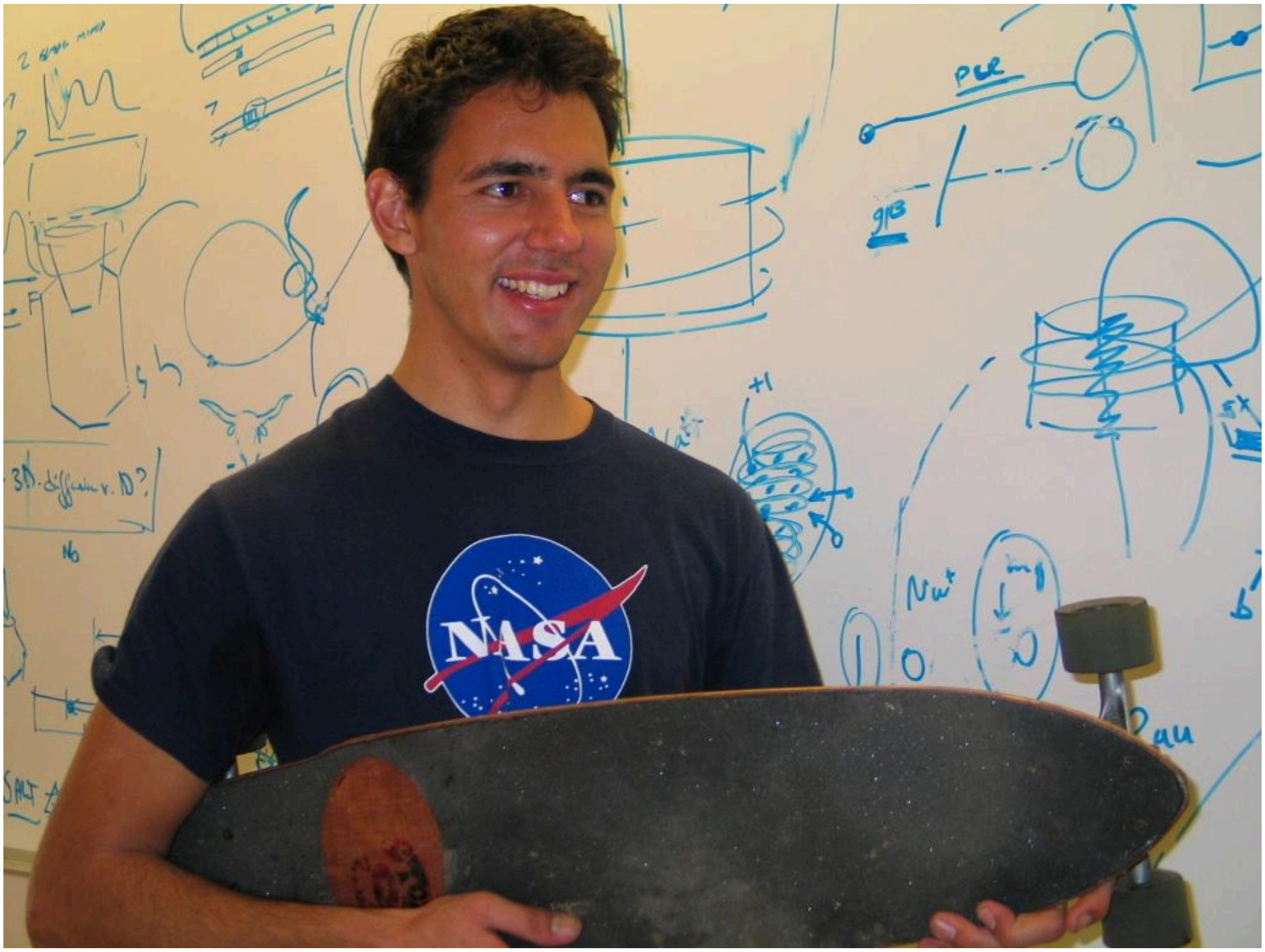
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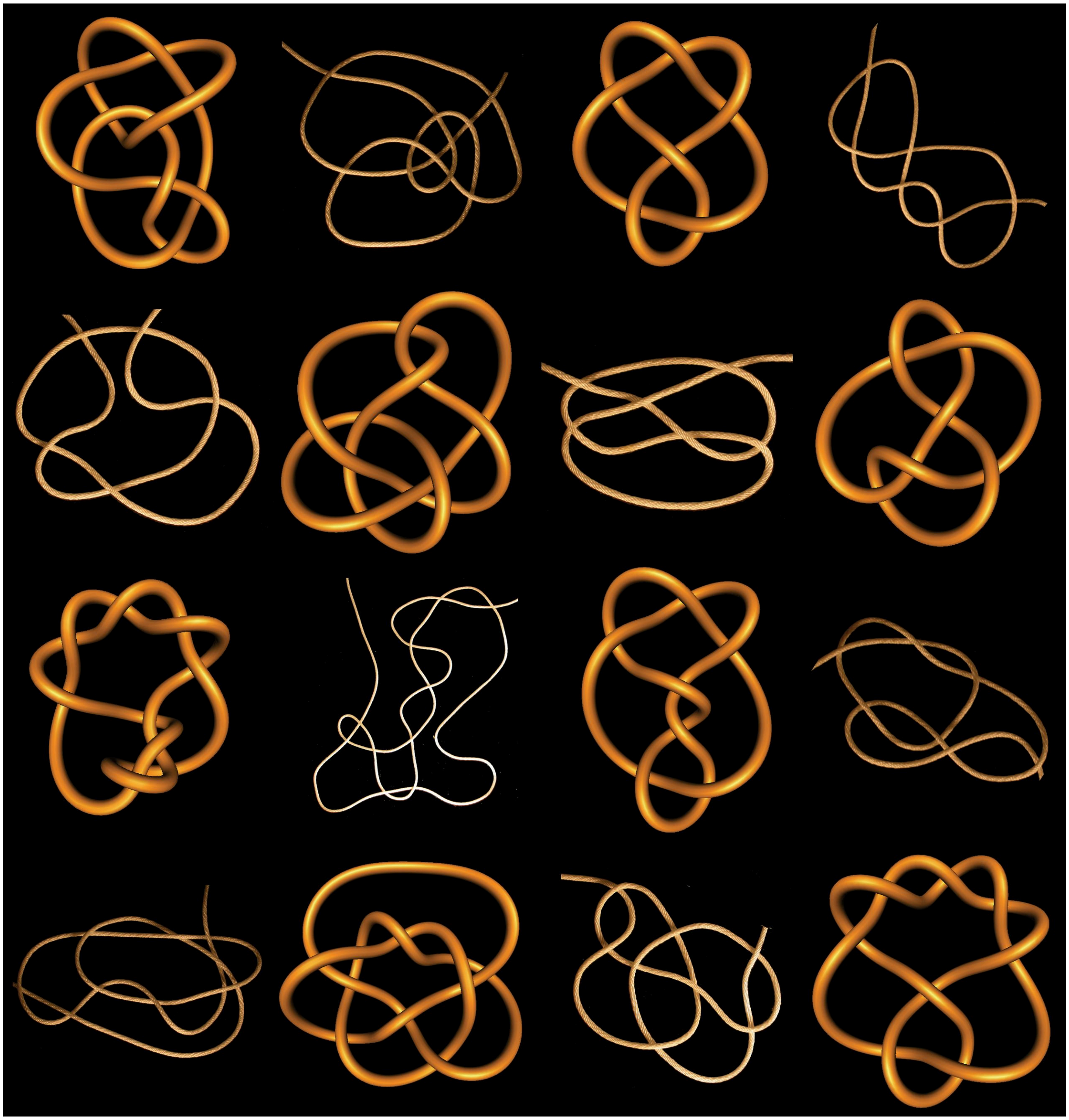

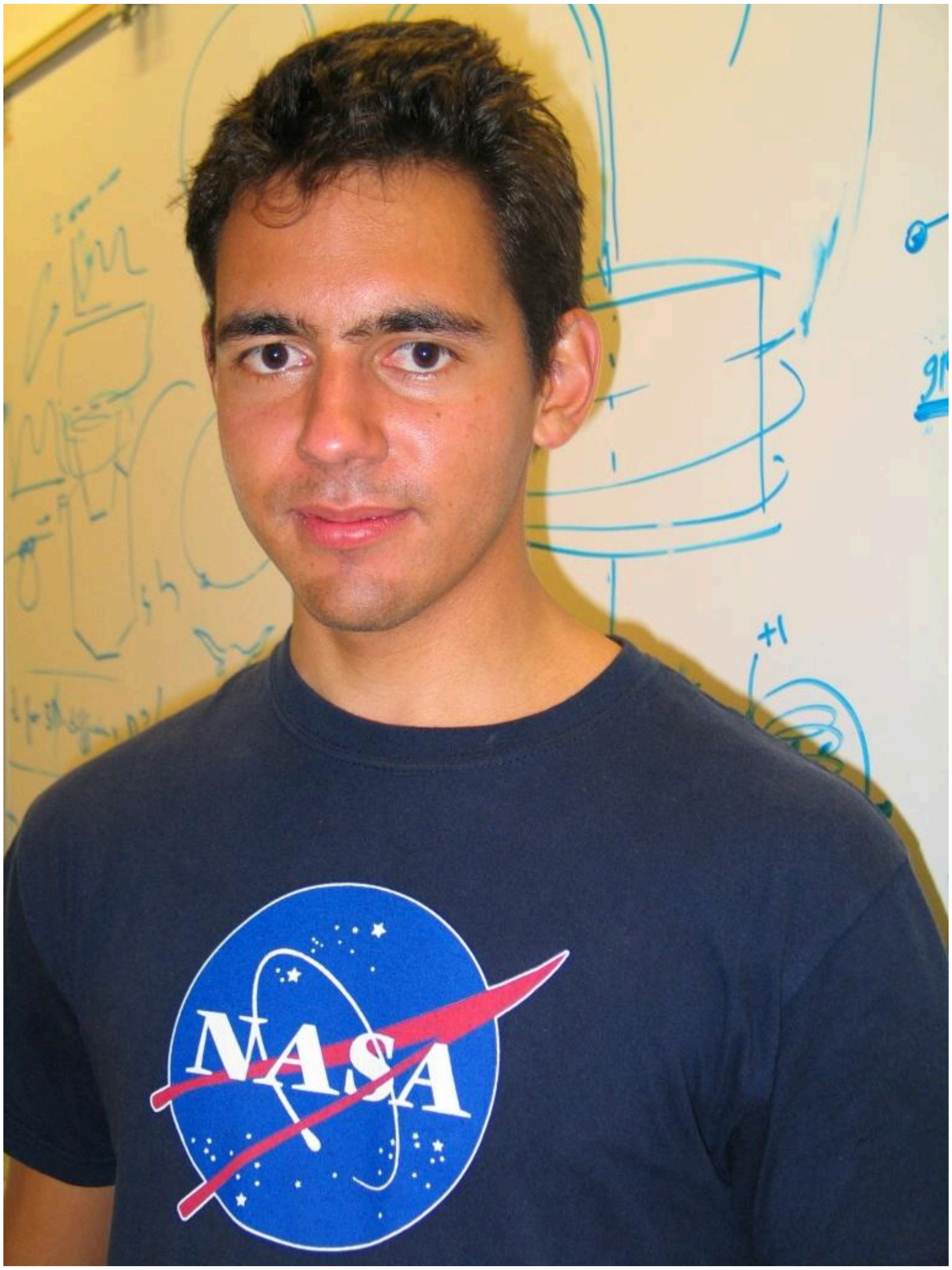
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