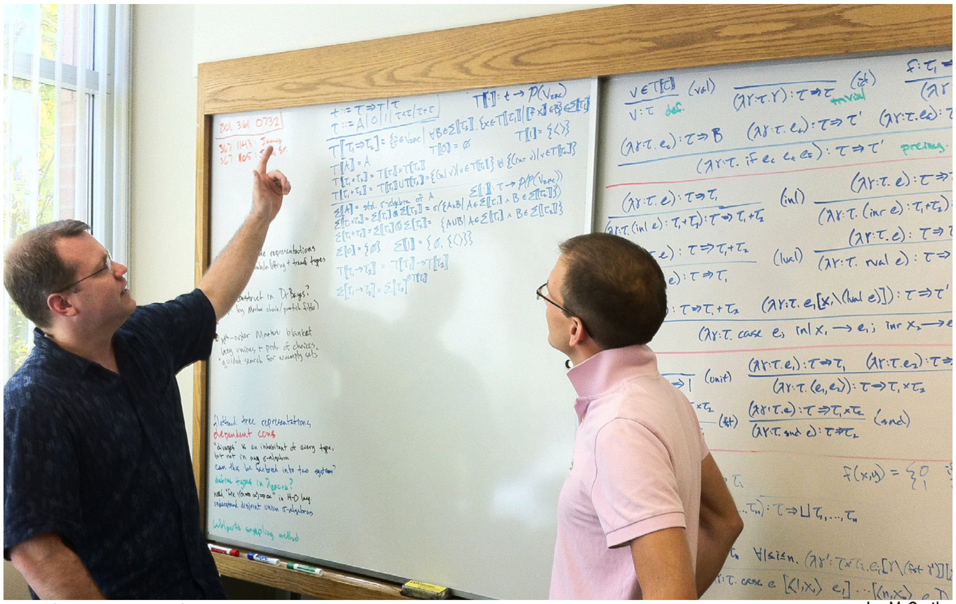
november | 2012

FACULTY newsletter

CPMS Physical and Mathematical Sciences

Get with the Program: Lambda ZFC Is Here



ABOVE Jay McCarthy and Neil Toronto work the math.

Jay McCarthy

You know why we love math? Unbeknownst to most, it helps computer scientists create spam filters.

Computer science grad student Neil Toronto created a new way to compute complicated math, making spam filters, voice commands, and artificial weather simulations that much easier to create.

This new groundbreaking programming language can save developers working with probabilistic mathematics substantial amounts of work.

"I made math more like a programming language," said Toronto, who created this distinct programming language, naming it Lambda-ZFC. Toronto originally created the programming language to help statisticians make more efficient spam filters, but it is now applicable to many different fields, including creating voice commands and scaling in digital imaging.

Instead of adapting the programming language to complicated math as people have tried in the past, Lambda-

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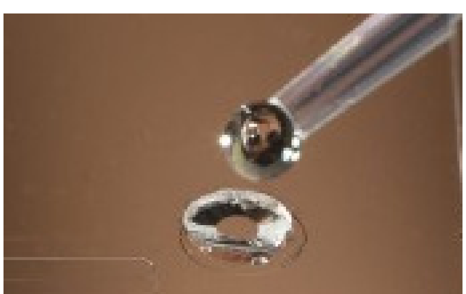
Measuring Molecules

Mark Philbrick, BYU Photography

ABOVE Debolina Chatterjee.



Mark Philbrick, BYU Photography

When someone develops liver cancer, the disease introduces a very subtle difference to their bloodstream, increasing the concentration of a particular molecule by just 10 parts per billion.

That small shift is difficult to detect without sophisticated lab equipment—but perhaps not for long. A new "lab on a chip" designed by Brigham Young University professor Adam Woolley and his students reveals the presence of ultra-low concentrations of a target molecule.

As the BYU researchers report in the journal Analytical Chemistry, their experiments detected as little as a single nanogram—one billionth of a gram—of the target molecule from a drop of liquid. And instead of sending the sample to a lab for chemical analysis, the chip allows them to measure with such precision using their own eyes.

"The nice thing about the system that we have developed is that this could be done anywhere," Woolley said. "Somebody could put the sample in, look at it, and have the result they need."

The trick is to line a tiny pipe with receptors that catch a specific molecule and allow others to pass by. When a drop of liquid is placed on the clear chip, capillary action draws the fluid through the channel, flowing up to one centimeter per second. As more of the target molecules are snagged by the receptors, the space constricts and eventually stops the flow.

How far the sample flows is a direct indication of the concentration of the target molecule (higher concentration = shorter distance, lower concentration = longer distance).

"The accuracy gained with this system should make it competitive with more expensive and complicated immunoassay systems," said Chuck Henry, a chemist at Colorado State University who was not affiliated with the project.

Woolley and his students hope their prototype will work as a blueprint for making inexpensive diagnostic tests for a variety of diseases and genetic disorders.

"There are a lot of molecules associated

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Dates to Note

Univ. Admin. Staff Award Nominations Due
Friday, Nov. 30

College Christmas Social
Friday, Dec. 7
11:30a.m., ESC Pendulum Court

College Award Nominations Due
Wednesday, Jan. 9

SRC Website Opens for Abstract Submissions
Tuesday, January 15

College Awards Banquet
Friday, January 18
6p.m., WSC Ballroom

Math is Art

"Math is beautiful. It's like art," Professor Gregory Conner says.

According to Dr. Conner, math is beautiful for what it is, in and of itself. Its beauty is not diminished even when the math cannot be directly applied in some way to our lives.

Mathematicians often discover theorems and develop proofs that may not immediately find an application in science or other fields, and Professors Gregory Conner and Chris Grant from the Department of Mathematics are no exception.

In 1964, the Ukrainian mathematician Oleksandr Mikolaiovich Sharkovsky discovered a beautiful theorem about periodic points of functions. Say F is a continuous function, and x and F(x) are real numbers. Let $F^2(x)$ denote F(F(x)), and $F^{n+1}(x) = F(F^n(x))$. Then if $F^n(x) = x$, x is called a periodic point of F, with period n. Sharkovsky proved the amazing fact that any function F that has a point of period 3 also must have periodic points with all other periods!

With little communication between the United States and the Ukraine during the cold war, two American mathematicians, Li and Yorke, independently discovered this theorem in 1975 and published it in their landmark paper, "Period Three Implies Chaos." Today, however, Sharkovsky is credited as the originator of the theorem that now bears his name.

One day after discussing Sharkovskii's Theorem with Dr. Grant, Dr. Conner mentioned the theorem to grad student Mark Meilstrup. Meilstrup guessed that Sharkovskii's Theorem could apply to more complicated spaces.

Finding how Sharkovskii's Theorem applied in more complicated spaces launched Conner, Grant, and Meilstrup on a journey. Meanwhile, the sheer beauty of mathematical insights such as Sharkovskii's Theorem holds great intrinsic value for those who have eyes to see it.

by: Curtis Penfold

College Grants

Mathematics Education

Keith Leatham and Blake Peterson
Sponsor: NSF
Title: Developing a Theory of Productive Use of Student Mathematical Thinking

Molecules continued from page 1

with diseases where concentrations around a nanogram per milliliter or less in blood are the difference between a disease state versus a healthy state," Woolley said.

Four students worked on the project, led by graduate student Debolina Chatterjee of New Delhi, India. She and fellow grad student Danielle Mansfield mentored two undergraduates on the project, Neil Anderson and Sudeep Subedi.

The experience helped Anderson gain admission into law school at Cornell, where he is studying patent law. Subedi is completing a degree in clinical laboratory science and plans to eventually return to his homeland of Nepal and help establish better medical infrastructure.

by: BYU News

Program continued from page 1

ZFC makes the math itself readable by the computer.

"It'll put grad students out of work," Jay McCarthy said with a chuckle. "So they can do more interesting tasks. I think people's time will be better spent exploring on the white board than exploring in the program."

There are some who can do the white board probabilistic math but can't translate the mathematics into a computer. Lambda-ZFC allows these people to do both instantaneously because it's designed to mimic the way one writes math.

"(Lambda-ZFC) sort of equalizes opportunity in who can produce that program," McCarthy said. "If you have steam shovels, you don't need big muscles. With Lambda-ZFC, you don't need big brains."

Lambda-ZFC's potential to improve computing probabilistic mathematics has not gone unrecognized. Last May, Toronto and McCarthy presented their work to an academic audience in Kobe, Japan.

by: Curtis Penfold

College Publications

Chemistry and Biochemistry

L.B. Bhuiyan, S. Lamperski, J. Wu, D. Henderson, "Monte Carlo Simulation for the Double Layer Structure of an Ionic Liquid Using a Dimer Model; a Comparison with the Density Functional Theory", Journal of Physical Chemistry B, 2012, volume 116/issue 34, pp. 10364-10370

D. Henderson, D. Jiang, Z. Jin, J. Wu, "Application of Density Functional Theory to Study the Double Layer of an Electrolyte with an Explicit Dimer Model for the Solvent", Journal of Physical Chemistry B, 2012, volume 116/issue 36, pp. 11356-11361

S. Bali, G. Bali, F.E. Huggins, M.S. Seehra, V. Singh, J.M. Hancock, R. Harrison, G.P. Huffman, R.J. Pugmire, R.D. Ernst, E.M. Eyring, "Synthetic Doped Amorphous Ferrihydrite for the Fischer-Tropsch Synthesis of Alternative Fuels", Industrial and Engineering Chemistry Research, 2012, volume 51/issue 12, pp. 4515-4522

Mathematics

R. Baker, A. Weingartner, "Some Applications of the Double Large Sieve", Monatshefte Für Mathematike Math, 2012, DOI 10.1007/s00605-012-0447-0

X.J. Li, "On Connes' Trace Formula for the Hankel Transformation of order −1/2", Science China Mathematics, 2012, volume 55/no.10, pp. 2125-2146

Mathematics Education

H.S. Lee, G. Kersaint, S. Harper, S. Driskell, K.R. Leatham, "Teachers' Statistical Problem Solving with Dynamic Technology: Research results across multiple institutions", Contemporary Issues in Technology and Teacher Education, volume 12/issue 3: http://www.citejournal.org/vol12/iss3/mathematics/article1.cfm

D.L. Corey, G. Phelps, D.L. Ball, J. Demonte, D. Harrison, "Explaining Variation in Instructional Time: An Application of Quantile Regression", Educational Evaluation and Policy Analysis, 2012, volume 34/issue 2, pp.146-163

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BRIGHAM YOUNG UNIVERSITY