Using math and medicine to wipe out deadly viruses

David Earn's mathematical models could lead to breakthrough vaccines

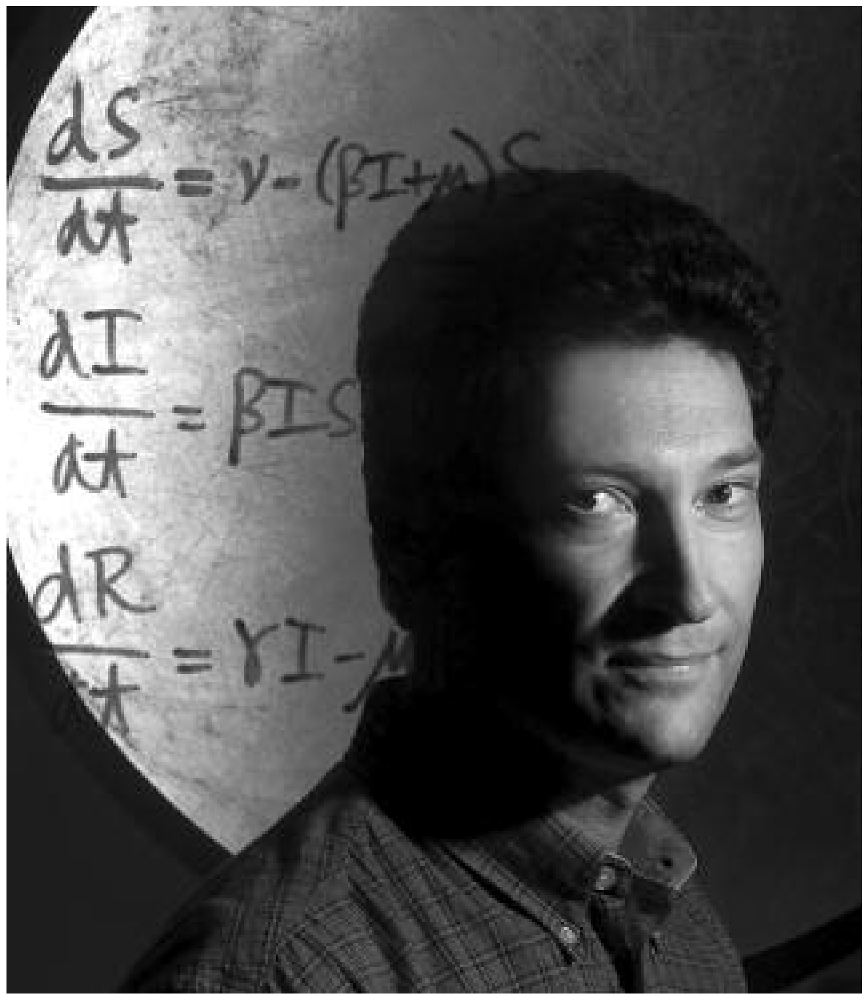
BY ANDREW VOWLES

SARS was all over the news headlines last spring when the phone began ringing in the office of McMaster's Prof. David Earn, mathematics and statistics.

The calls came from several directions, from a physician at Scarborough Grace Hospital – site of the original cases of severe acute respiratory syndrome in Canada – to government agencies, notably Health Canada and the Ontario Ministry of Health.

Their question: Could Earn use his math smarts applied earlier in modeling disease epidemics and conservation of wildlife species to help understand – and hopefully help to stop – the spread of this deadly new infection?

Closer to home, another call came from Prof. Mark Loeb, pathology and molecular medicine, who regularly finds himself tapped during health crises as an infectious diseases consultant. Since this spring, Loeb has been leading a research team studying the diagnosis and epidemiology of SARS as part of a $1.7-million research strategy funded by the Canadian Institutes for Health Research (CIHR).



"We wanted a comprehensive approach to SARS and felt that David's expertise in mathematical modeling would be an important asset to our proposed research," says Loeb, referring to Earn's models of measles and influenza outbreaks.

By mid-summer, SARS had more or less receded from the news, but the number-crunching was still going on in Earn's office. As a theme leader in the Canadian SARS Research Network, the McMaster mathematician is using travel and hospital statistics to model the capacity of Canada's health care system to deal with this and other disease threats.

Predicting when the next such outbreak might occur is impossible, says Earn, who had already received a CIHR New Investigator award last year and an award from the Rx&D Health Research Foundation this year. But it's important to learn more about the spread of diseases, and our ability to resist them, in order to meet the next threat head-on.

Earn uses mathematics to model infectious disease transmission. A breakthrough reported in 2000 revealed the mechanism behind mysterious irregularities in historical measles outbreaks. "We discovered that it's possible to predict changes in the frequency of measles epidemics from birth rates and vaccination levels." More recently, Earn and his group have shown that simple models can also explain the outbreak patterns of rubella, chicken pox and whooping cough.

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He has also developed a new way to design vaccination programs. "I'm using mathematical techniques to determine immunization strategies that would synchronize epidemics, especially measles," he says, explaining that new types of mass vaccination campaigns might cause the trough in an epidemic cycle to occur simultaneously around the world, increasing the chance that the disease will disappear everywhere.

About half of vaccine-preventable deaths in the world are caused by measles. Some 30-40 million cases of measles occur each year and about 750,000 people die from it, mostly in Africa.

Another recent project investigated the cost-benefits of voluntary versus mass-imposed vaccination for smallpox. Earn says mass vaccination against smallpox would save lives in the event of a bioterrorism attack. But would you still want to impose vaccinations – and risk the side effects of the vaccine itself, including deaths – if no attack took place?

He hopes agencies such as the World Health Organization might use his research to design more efficacious control programs. "It would give me a lot of satisfaction if a vaccination strategy that I helped develop was used and helped to save lives."

For Earn, working on disease eradication is a kind of mirror image of another way he uses math, to help conserve endangered wildlife species. "In one case we want to cause extinctions, in the other case we want to prevent them."

He has shown that conservation corridors, which connect patches of habitat and allow endangered animals to move among them, have the potential to make matters worse for the very species they aim to protect. "The trouble is that connectivity promotes synchrony and – like in the epidemic problem – synchrony promotes global extinction," instead of allowing isolated groups to survive.

Neither epidemiology nor ecology had been part of Earn's initial plans. The Winnipeg native had studied mathematics and the dynamics of solar systems and galaxies, first at the University of Toronto, then at the University of Cambridge.

As a post-doctoral fellow, he was swayed from physics to biology after his wife asked for help in modeling the evolution of parental care in fish (Prof. Sigal Balshine is a faculty member in the Department of Psychology).

Unlike physics, in which he might be refining mathematical methods to make progress on well-defined problems, he says that for many biological problems "the greatest challenge is to figure out what the right question is."

Motivated by his desire to contribute to improving public health, he has begun work with Prof. Julia Abelson in McMaster's Centre for Health Economics and Policy Analysis on how best to turn mathematical research results into information that policy makers can use. "It would obviously be a shame if valuable research results were not passed on in a useful way to the people who make policy decisions."