

UC SANTA BARBARA

# THE *Current*

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## **Internet Game Provides Breakthrough in Predicting the Spread of Epidemics, Report Scientists**

Using a popular internet game that traces the travels of dollar bills, scientists have unveiled statistical laws of human travel in the United States, and developed a mathematical description that can be used to model the spread of infectious disease in this country. This model is considered a breakthrough in the field.

"We were confident that we could learn a lot from the data collected at the [www.wheresgeorge.com](http://www.wheresgeorge.com) bill-tracking website, but the results turned out far beyond our expectations," said Lars Hufnagel, a post-doctoral fellow at the Kavli Institute for Theoretical Physics at the University of California, Santa Barbara and co-author of an article describing the research in the January 26 issue of the journal Nature.

The worldwide spread of disease -- particularly pandemics with disastrous consequences for human health and economics -- has become a serious threat in the globalized world of intense international trade and travel. The threat of bird flu, the possible emergence of a new human "supervirus," and the potential of a worldwide flu pandemic, make predicting the spread of these diseases more urgent than ever.

Historical pandemics, like the 14th-century plague, moved slowly in waves across geographical areas, because in the Middle Ages people could typically only travel a few kilometers a day. The speed with which epidemics could spread was thus kept in check. It took the plague three years to move up the European continent, south to north, with an average rate of spread of about two kilometers a day.

"But today people move great distances in short time periods, as well as short distances, and they use variable means of transportation," said Hufnagel. "Thus we can expect that future pandemics will spread according to other rules, and more quickly. The rapid worldwide spread of SARS (severe acute respiratory syndrome) has already demonstrated this."

Searching for a way to model the modern spread of disease became the focus of discussions among the co-authors: Theo Geisel, director of the Max Planck Institute for Dynamics and Self Organization and professor at the University of Goettingen; Dirk Brockmann, a postdoctoral fellow at the Max Plank Institute for Dynamics and Self Organization; and Hufnagel. Following a conference in Montreal, Brockmann met with a friend in Vermont, a cabinetmaker, who showed him the internet game for tracking the movement of dollar bills, located at [www.wheresgeorge.com](http://www.wheresgeorge.com). Participants can register a dollar bill, of any denomination, and monitor its geographic circulation.

The physicists were intrigued: Like viruses, money is transported by people from place to place. They found that the human movements follow what are known as universal scaling laws (from local to regional to long-distance scales). Using the game data, they developed a powerful mathematical theory that describes the observed movements of travelers amazingly well over distances from just a few kilometers to a few thousand. The study represents a major breakthrough for the mathematical modeling of the spread of epidemics.

"Since we can't track people with tracking devices, like we do animals, we needed to get data that provided us with millions of movements of individuals," explained Hufnagel. Scientists are already familiar with similar scaling laws from physical and biological systems. "What is amazing about these particular scaling laws is the fact that they are determined by two universal parameters only. This result surprised us all."

Added Brockmann: "We recognized that the enormous amount of data, as well as the geographical and temporal resolution of bill-tracking, allowed us to draw conclusions about the statistical characteristics of human travel, independent of which means of transportation people use."

Geisel said, "We are optimistic that this study will drastically improve predictions about the geographical spread of epidemics."

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† About the Illustration

Each line in this illustration symbolizes the geographic movement of a single U.S. dollar bill (or a bill in any denomination) from either Seattle(blue) or NewYork (yellow) to various destinations in the country. The bills traveled for less than a week.

Also shown is the population density (blue for low, yellow and red for high)in the Eastern United States.

Credit: UCSB and the Max Planck Institute for Dynamics and Self Organization

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