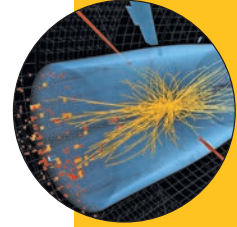


# Contents

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## 2 **Massive Breakthrough**

In 1963, Peter Higgs predicted the existence of the Higgs field, which explains why many subatomic particles have nonzero mass. This prediction was based on a mere page of mathematical calculation and an inspired analogy with the Landau-Ginzburg theory of phase transitions. Almost half a century and more than \$9 billion later, experimental physicists at CERN finally chased down the Higgs boson, the most elusive quarry in physics. The discovery filled in the last missing piece of the Standard Model of quantum physics, and spectacularly vindicated the use of abstract symmetry principles to discover new physical phenomena.



## 16 **Tubing through Hyperspace**

In 2012, geometers in rapid succession solved three open problems concerning optimal geometries of tori (inner tubes). The Willmore Conjecture identified the torus with least bending energy; the Lawson Conjecture identified the torus in the hypersphere (a sphere in four-dimensional space) with the least surface area; and the Pinkall-Sterling Conjecture classified all of the tori in the hypersphere that minimize area subject to a volume constraint. Tubing has never been so much fun!



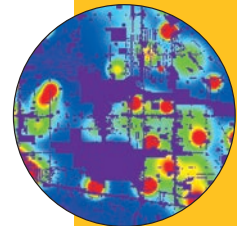
## 30 **Tsunamis: Learning from Math, Learning from the Past**

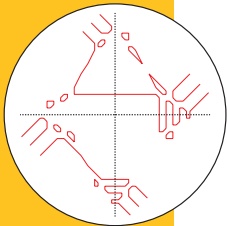
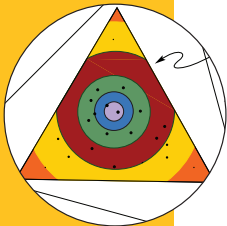
The great Japanese tsunami of 2011 killed more than 15,000 people in a country that had been better prepared for tsunamis than any other in the world. The tragedy highlighted gaps in our scientific understanding of this hugely destructive natural phenomenon, and even more so in the public's understanding. It also pointed out some ways in which mathematical models got it right, but not fast enough.



## 46 **Today's Forecast: Ten Percent Chance of Burglary**

An interdisciplinary team at UCLA discovered how to adapt a mathematical model developed for earthquake prediction to identify likely crime “hot spots.” Two field tests of their software were resounding successes, and predictive policing was recognized in *Time* magazine and other media outlets as one of the top scientific discoveries of 2011.





## 56 **Topologists Cross Four Off "Bucket List"**

Three decades ago, three-dimensional topology seemed like a wild, untamed jungle of disparate examples. Then William Thurston proposed a series of conjectures that brought some order to the chaos. In 2012, just months before Thurston's death, the Virtual Haken Conjecture and Virtual Fibration Conjecture were finally proved, showing that almost all three-dimensional manifolds are descended from templates constructed in an elementary fashion.

## 68 **Mathematicians Do the Twist**

Rubik's cube, the mathematician's favorite toy, continues to attract new fans and inspire new research. While "speed-cubers" developed new algorithms (and manual dexterity) to solve the cube in less than 10 seconds, mathematicians proved that an omniscient being could always solve the classic, 3-by-3-by-3 cube in 20 moves or less.

## 84 **The Right Epidemic at the Right Time**

In 2009 the world experienced its first flu pandemic in forty years. Fortunately it turned out much milder than the three great pandemics of the twentieth century, but it provided an ideal opportunity to test a variety of mathematical simulations in real time. Conclusions: The simulations worked pretty well, and communications between modelers and field workers were excellent, but the late delivery of vaccine would have been a fiasco in a worse epidemic.

## 98 **Thinking Topically**

Topic modeling is a new statistical technique named after its ability to identify topics (such as genetics or climate change) in a large body of documents. While still in its early days, it has proved hugely popular in the fields of "digital humanities" and it might enable social-networking websites to respond automatically and anonymously to cyber-bullying.

## 112 **Thinking Tropically**

Blessed (or perhaps cursed?) with a catchy name, tropical geometry enables mathematicians to solve difficult problems in classical algebraic geometry by making simple combinatorial models that look a lot like stick figures. This new type of geometry also has surprising applications to string theory in physics, evolutionary trees in biology, and the scheduling of trains.