

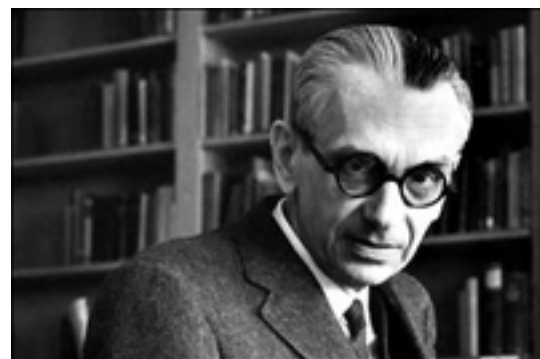
TEMPLETON REPORT

NEWS FROM THE JOHN TEMPLETON FOUNDATION

June 25, 2008

Pushing the Boundaries of Mathematics

Even in the rarefied world of advanced mathematics, some areas of study are recognized as particularly difficult. The great logician, mathematician, and philosopher Kurt Gödel (1906-78) made a specialty of such investigations. In recognition of his genius, and as part of a multiyear celebration of the 100th anniversary of his birth, the Kurt Gödel Society of Vienna, with the support of the John Templeton Foundation, recently announced the winners of five Kurt Gödel Centenary Research Fellowships.



The 2008 Fellows were chosen in an open, international competition that was judged by a board of seventeen eminent jurors. They were announced at a colloquium held on April 27 at the University of Vienna. In the pre-doctoral category, the winning papers were submitted by David Fernández Duque of Spain (“Non-Deterministic Semantics for Dynamic Topological Logic”) and Pavel Hrubes of the Czech Republic (“On Lengths of Proofs in Non-Classical Logics”). Both were awarded fellowships of \$60,000 a year for two years.

Winners in the post-doctoral category were Andrey Boykin of Russia (“Independence Results in Concrete Mathematics”) and Peter Koellner of Canada (“On Reflection Principles”). Both will receive \$80,000 a year for two years. Thierry Coquand of France was the winner in the senior category for a study of the “Space of Valuations” and was given a one-year award of \$120,000. All the papers will be published in a special issue of the *Annals of Pure and Applied Logic*.



In Vienna, Dr. John M. Templeton, Jr., the chairman and president of JTF, unveiled a new commemorative plaque honoring Gödel (see photo). Speaking to the colloquium, he affirmed the Foundation’s strong interest in pure mathematics. “I admire Gödel’s stubborn questioning, his determination to get to the root of fundamental issues,” he told the gathered scholars. Dr. Templeton also expressed high hopes for another of the Foundation’s research endeavors, “Exploring the Infinite,” which was launched in 2007. The program is intended to develop a global network of mathematicians and scientists with an interest in infinity. Its initial phase, on mathematics and mathematical logic, was recently launched with the announcement of twenty scholars who will share \$1.2 million in research grants. Their research will cover such topics as “The Infinite in Combinatorics and Number Theory,” “The Study of Unprovability,” and “Effective Mathematics of the Uncountable.” Future phases of “Exploring the Infinite” will support research in such disciplines as physics, cosmology, biology, philosophy, and philosophical theology.

For this program, as for the Gödel Centenary Research Fellowships, the Templeton Foundation is indebted to Dr. Harvey Friedman, who chaired the juries that judged submissions to both competitions. Friedman is Distinguished University Professor of Mathematics, Computer Science, Philosophy, and Music at Ohio State University. His many accomplishments include an

entry in the *Guinness Book of World Records* as the “youngest professor,” for his appointment at Stanford in 1967, at age 18, after receiving his doctorate from MIT. Both programs, he told the *Templeton Report*, demonstrate that the Foundation “is interested in the fundamental philosophical issues in math, as it is in physics.” Dr. Hyung Choi, a mathematical physicist and an expert consultant to JTF, agrees that the Gödel and infinity programs are on the cutting edge of mathematical research. “They are not mainstream math,” he explains. “They are pushing the boundaries of math, and even its fundamental foundations and philosophical ends.”

Choi says it is especially instructive to consider these grants alongside two symposia that JTF supported at Princeton University last fall to mark the 50th anniversary of the death of the scientific and mathematical polymath John von Neumann. “Deep Beauty: Mathematical Innovation and the Search for an Underlying Intelligibility of the Quantum World” celebrated Von Neumann’s legacy, with special attention to his pathbreaking text, *Mathematical Foundations of Quantum Mechanics* (1932). “Games, Groups, God(s) and the Global Good” explored the uses and limits of game theory in explaining ethical behavior and illuminating the nature and dynamics of moral order and moral transformation. The first of these was about “the application of math to physics,” Choi said. The second was “math as applied to ethics.”

NOTEBOOK

The Chemical Basis of Trust

Trust is essential to healthy social interactions, but how do we decide whether we can trust strangers? An article based on research supported by the Templeton Foundation and published in the June issue of *Scientific American* argues that the hormone oxytocin enhances our ability to trust strangers who exhibit non-threatening signals.

The article, “The Neurobiology of Trust,” by Paul J. Zak, is based on original research with an experimental situation that the author calls the “trust game.” It is a modification of a similar game developed in the mid-1990s by the experimental economists Joyce Berg, John Dickhaut, and Kevin McCabe. The game allows test subjects to transfer their money to a stranger if they trust the stranger to reciprocate by transferring more back.

When we are trusted, Zak found, our brains release oxytocin, which makes us more trustworthy; the subjects with the highest levels of oxytocin returned the most money to their partners. Moreover, the rise in oxytocin levels, and not the absolute level, made the difference. Zak also found that subjects who inhaled an oxytocin nasal spray were more likely to trust others. Those given oxytocin transferred 17 percent more money than control subjects who inhaled a placebo. Twice as many subjects who received oxytocin gave all their cash to their partners.

Oxytocin is best known as the hormone that induces labor in pregnant women. But Zak maintains that its role in the development of trust has implications for a range of important issues, from the growth of wealth in developing countries to the nature of diseases such as autism to the physiological basis of virtuous behaviors. A professor of economics and founding director of the Center for Neuroeconomics Studies at Claremont Graduate University, Zak also serves as clinical professor of neurology at Loma Linda University Medical Center. His new book, *Moral Markets: The Critical Role of Values in the Economy*, was also supported by JTF, and was published by Princeton University Press this year.



The Neural Basis of Justice

Is it more just to maximize a good regardless of its distribution, or must the good be distributed equitably? And do our emotions affect our decisions in such matters? Distributive justice concerns the fairness of how individuals and societies allocate benefits and burdens. Though it is central to social choice theory, moral psychology, and welfare economics, its psychological and neural underpinnings are poorly understood. An article reporting original research that advances our understanding of the topic was published in the May issue of *Science*. The lead author of the article was Templeton grantee Steven R. Quartz, with co-authors Ming Hsu and Cédric Anen.

For “*The Right and the Good: Distributive Justice and Neural Encoding of Equity and Efficiency*,” Quartz and his colleagues asked 26 adult subjects to decide how to allocate money to children in an orphanage in northern Uganda, while undergoing functional magnetic resonance imaging (fMRI). The subjects had to decide between various allocations that either gave more money to one child (thus maximizing the overall good) or divided a smaller sum between two children (thus maximizing fairness). They found that a sense of fairness is fundamental to distributive justice, but that it is rooted in emotional processing, rather than in rational calculation.



Quartz is director of the Social Cognitive Neuroscience Laboratory at the California Institute of Technology and an associate professor in the Division of Humanities and Social Sciences and the Computation and Neural Systems Program. He plans to continue the work published in *Science*, with the hope of establishing an approach to ethics that applies his findings to other real-world problems.

For more information, write to communications@templeton.org.

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