L. Miles, University of Washington; **Sidney R. Nagel**, University of Chicago; **June B. Nasrallah**, Cornell University; **William D. Nix**, Stanford University.

Helen R. A. Quinn, Stanford Linear Accelerator Center; **Michael Rosbash**, HHMI and Brandeis University; **A. Catharine Ross**, Pennsylvania State University; **Linda J. Saif**, Ohio State University, Wooster; **Paul L. Schechter**, MIT; **William H. Schlesinger**, Duke University; **Robert J. Silbey**, MIT; **Bruce D. Smith**, Smithsonian Institution, Washington, D.C.; **Claude M. Steele**, Stanford University; **Arthur L. Stinchcombe**, Northwestern University.

Robert M. Stroud, UC San Francisco; **Joseph S. Takahashi**, HHMI and Northwestern University; **Saul A. Teukolsky**, Cornell University; **Michael F. Thomashow**, Michigan State University; **James M. Tiedje**, Michigan State University; **James L. Van Etten**, University of Nebraska; **Dale J. Van Harlingen**, University of Illinois, Urbana-Champaign; **Brian A. Wandell**, Stanford University; **Arthur Weiss**, HHMI and UC San Francisco; **Paul A. Wender**, Stanford University; **Eli Yablonovitch,** UC Los Angeles; **Masashi Yanagisawa**, HHMI and University of Texas Southwestern Medical Center.

Newly elected foreign associates, their affiliations at the time of election, and their country of citizenship (in parentheses) are as follows:

Edouard Brezin, École Normale Supérieure, Paris (France); **Haim Brezis**, Université Pierre et Marie Curie, Paris (France); **Juan Carlos Castilla**, Pontificia Universidad Católica de Chile, Santiago (Chile); **Zhu Chen**, Shanghai Second Medical University (People's Republic of China); **Luis Herrera-Estrella**, National Polytechnic Institute, Guanajuato (Mexico); **Avram Hershko**, Technion–Israel Institute of Technology, Haifa (Israel); **Herbert Kroemer**, UC Santa Barbara (Germany); **Rosine Lallement**, Centre National de la Recherche Scientifique, Verrières-le-Buisson (France); **Linda Manzanilla**, National Autonomous University of Mexico (Mexico).

Ryoji Noyori, Nagoya University (Japan); **Giorgio Parisi**, University of Rome (Italy); **Martin C. Raff**, University College London, U.K. (Canada); **Obaid Siddiqi**, Tata Institute for Fundamental Research, Bangalore (India); **Tadatsugu Taniguchi**, University of Tokyo (Japan); **Andrzej K. Tarkowski**, Warsaw University (Poland); **Janet Thornton**, European Bioinformatics Institute, Cambridge (United Kingdom); **Alan C. Walker**, Pennsylvania State University (United Kingdom); **Ada Yonath**, Weizmann Institute of Sciences, Rehovot (Israel).

QUANTUM PHYSICS

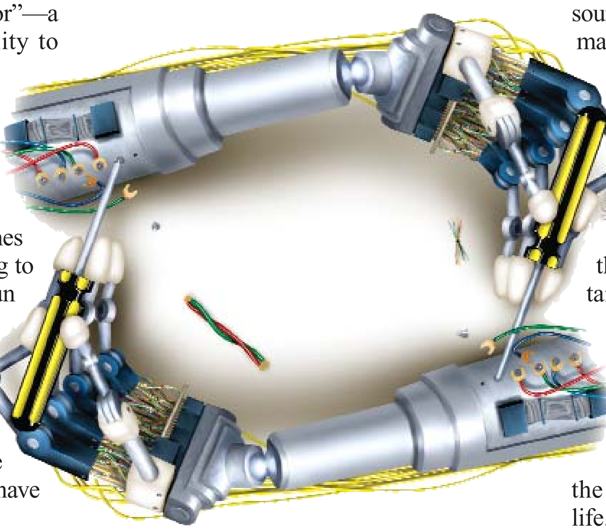
In Clone Wars, Quantum Computers Need Not Apply

If bloodthirsty legions of identical self-replicating robots bent on the destruction of humanity haunt your dreams, rest easy. Science has proven that they can't exist—at least not if they have quantum brains. In a paper submitted to *Physical Review Letters*, two physicists have shown that it is impossible to build a quantum "universal constructor"—a quantum computer that has the ability to spawn perfect copies of itself.

The idea of a universal constructor goes back more than 60 years to the dawn of the computing age, when John von Neumann, one of the architects of computing theory, started pondering whether self-replicating machines could exist. "It was a step toward trying to understand a living system," says Arun Pati, a physicist at the Institute for Physics in Bhubaneswar, Orissa, India. After all, most living creatures spend an excessive amount of time and effort trying to make copies of themselves, so if machines could be "alive" in some manner, they would have to be able to reproduce.

Indeed, they can. Von Neumann designed a complex computer program that outputs an exact duplicate of itself—first making a copy of its structure and then breathing life into the copy by giving it a set of instructions that tell it how to replicate. When the duplication process is complete, there are two identical programs capable of making even more identical copies. Case closed.

Now, however, many questions of the early days of computer science—including von Neumann's universal-constructor project—have become interesting again. Many computer scientists and physicists are turning their attention toward quantum computers—logical entities that are at once more powerful and more restricted than their classical counterparts. For example, a quantum computer can theoretically crack public-key encryption codes that are far beyond the abilities of classical computers. On the other hand, quantum computers are hobbled by the "no-cloning" rule, which states that a quantum computer can't make an exact copy of a piece of data without destroying the original—something that ordinary computers do with aplomb, much to the music industry's chagrin. So all the old questions of classical computing, such as whether there can be a universal constructor, are being asked again in the quantum domain.



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Now Pati and Samuel Braunstein of the University of Wales, Bangor, have answered that question with a resounding no. By closing loopholes in the no-cloning rule, they showed that in a universe with finite resources, a quantum robot would be unable to make a perfect copy of itself. So, in a sense, argues Pati, it could never be "alive." That could be bad news for those who speculate that life might have some sort of quantum-mechanical nature.

Not quite, says Seth Lloyd, a physicist at Massachusetts Institute of Technology in Cambridge. Lloyd says that Pati and Braunstein are almost certainly correct, but he adds that a "living" machine wouldn't have to replicate itself exactly—an almost-perfect copy would do just fine. "You can reproduce it to an arbitrary degree of precision," he notes. "That's good enough for me."

Braunstein agrees and downplays the proof's implications for the nature of life. "Life as something able to reproduce itself is all nice and good, but it's very simplistic," he says. To Braunstein, the real value of figuring out what quantum computers can and can't do is that it goes to the heart of what makes quantum mechanics so weird. "It's a very interesting question—looking at machines that are impossible," he says. "It gives us a language and a powerful way of thinking of the difference between the classical and the quantum—and about what makes quantum mechanics really tick."

–CHARLES SEIFE