uptake of amines to aid RNA folding. Again, no additional enzymes need to be evolved for this basic form of energy capture and storage, which is only a consequence of the physical properties of the vesicles.

These results demonstrate that simple physicochemical properties of elementary protocells can give rise to essential cellular behaviors, including primitive forms of Darwinian competition and energy storage. Such pre-existing, cooperative interactions between the membrane and encapsulated contents could greatly simplify the transition from replicating molecules to true cells. They also suggest intriguing possibilities for further investigation. For example, a corollary of vesicle competition is that a charged genetic polymer, such as nucleic acid, would be much more effective at driving membrane uptake than an electrically neutral polymer, because most of the osmotic pressure is due to counterions associated with the charged polymer. Could this influence the natural selection of the genetic material itself? Furthermore, competition for membrane molecules would favor stabilized membranes, suggesting a selective advantage for the evolution of cross-linked fatty acids (e.g., di- and triglycerides) and even the phospholipids of today. Greater membrane stability leads to decreased dynamics, however, and the evolution of transmembrane proteins. Such increased protein-membrane interactions would enhance stability, suggesting a selective advantage for membranes with a higher degree of organization. Greater membrane stability would thus enhance the efficiency of protocells, leading to increased cellular diversity and complexity.

References

2006 Grand Prize Winner
Irene A. Chen, the author of the prize-winning essay and a North American regional winner, was born in San Diego, California, to Taiwanese-American parents. She has had a fascination with science from a young age. As a high school senior, she won the Westinghouse Science Talent Search for research done under the direction of Carol MacLeod of the University of California, San Diego. She majored in chemistry at Harvard University, and as an undergraduate studied molecular recognition in the laboratory of Gregory Verdine. Dr. Chen stayed at Harvard to enter the M.D.-Ph.D. program. Under the mentorship of Jack Szostak, she investigated the biophysics of the origin of life—work that was recognized with a 2005 Harold M. Weintraub Graduate Student Award. She is currently finishing medical school at Harvard and plans to continue to study molecules and evolution.

Regional Winners
North America: Dianne Schwarz for her essay “Unraveling the Mysteries of Small RNAs.” Dr. Schwarz received a B.S. degree from the State University of New York at Albany. She did undergraduate research in the laboratory of Carole Stewart, where she studied the function of short interspersed repeats in primate DNA. As a graduate student in Phillip D. Zamore’s lab at the University of Massachusetts Medical School in Worcester, she characterized the RNA interference (RNAi) pathway in Drosophila and humans and investigated possible therapeutic applications of RNAi to diseases such as amyotrophic lateral sclerosis. Dr. Schwarz’s thesis work was recognized with a 2005 Harold M. Weintraub Graduate Student Award. She is currently a Jane Coffin Childs postdoctoral fellow in the lab of Erin K. O’Shea at Harvard University, where she studies stress response in yeast.

Europe: Bernhard Loll for his essay “Photosystem II, a Bioenergetic Nanomachine.” Dr. Loll was born in Ravensburg, Germany. He studied chemistry at Albert-Ludwigs-Universität in Freiburg, Germany, and received his diploma in 2000. During this time he worked in the group of Georg E. Schulz, and this stimulated his interest in biochemistry and protein crystallography. He continued to follow these interests by pursuing Ph.D. work in the group of Wolfram Saenger at Freie Universität Berlin. There, Dr. Loll elucidated the three-dimensional structure of photosystem II, in work done in cooperation with the group of Athina Zouni at Technische Universität Berlin. Dr. Loll defended his Ph.D. in February 2005 and is currently a postdoctoral scientist in the group of Anton Meinel at the Max-Planck-Institut für Medizinische Forschung in Heidelberg.

All Other Countries: Ron Milo for his essay “Simple Building Blocks for Complex Networks.” Dr. Milo grew up in Kfar Saba, Israel. As an undergraduate he studied physics and mathematics at the Hebrew University in Jerusalem. His Ph.D. research, conducted under the guidance of Uri Alon at the Weizmann Institute of Science in Rehovot, centered on analyzing complex biological networks with the use of network motifs. Dr. Milo continued as a postdoctoral fellow in the Alon group, where he measured the variability and memory of protein levels in human cells. His doctoral research was recognized with a Dimitris N. Chorafas Foundation Award in 2004 and the institute’s John F. Kennedy Award in 2006. Dr. Milo is currently a fellow in the Department of Systems Biology at Harvard Medical School. In his spare time he enjoys investigating the beauty of nature in New England together with his wife and daughter.

For the full text of essays by the regional winners and for information about applying for next year’s awards, see Science Online at www.sciencemag.org/feature/data/prizes/ge/index.dtl.