Why Evolution Drives Some Cells to Altruism

September 18 2006

Nature has been capitalizing on the benefits of a specialized labor force long before Henry Ford made it popular. New research suggests the same principles Ford used have driven the evolution of complex organisms.

According to Richard E. Michod of The University of Arizona in Tucson, specialization has permitted the development of multi-cellular organisms – everything from worms to whales.

“The history of life tells us that new forms of life have emerged by the grouping together of previous forms of life,” said Michod, who heads the UA's department of ecology and evolutionary biology.

When does the existence of the collective become more important than that of the sum of its parts? Or as Michod writes: "How does a group become an individual?"

Consider a hive of bees. Worker bees gather food, fix the hive and feed the kids. However, they cannot reproduce, so a hive of all workers would go extinct when the last worker died.

Fortunately, other bees in the colony can reproduce.

Neither type of bee could persist on its own, but together they can create a lasting community. Michod’s research explains how such specialization has been favored by evolution.

His article, “The group covariance effect and fitness trade-offs during evolutionary transitions in individuality,” was published in the June 2 issue of the *Proceedings of the National Academy of Sciences*. A Fulbright research fellowship and the UA's College of Science supported the research.

Although the beehive example illustrates specialization, Michod wanted to start with a simpler biological system. He decided to examine how single cells become specialized when banding together with others, something like the green algae, Volvox, that live in spherical colonies comprised of 500 to 50,000 individual cells. Volvox cells can specialize during development.

Michod developed a mathematical model and tested it with computer simulations to study the importance of specialization in determining the fitness of a group of cells. In this case, fitness is not their physiological health, but how well they pass on their genes to future generations.

When the simulation first begins, the individual cells vary slightly in their skills at the two key factors that determine the overall fitness of the cell colony. Those factors are reproducing and the day-to-day activities of living, which Michod calls viability.

Although each cell has the ability to specialize, doing so will not help a cell that's going it alone. However, the computer model shows that when living in a group, things are different.

As the colony evolves over many generations, individual cells make trade-offs. In the end, about half the cells dedicate themselves to reproduction and the other half to viability. For those cells that focus on reproduction, viability goes down. The cells that specialize on viability sacrifice their ability to reproduce.

Michod found that the more different the two types of cells are, the higher the fitness of the colony.

His research shows that although specialization costs each individual cell some of its own personal fitness, the net result is that the colony as a whole benefits. In terms of fitness, the whole colony is greater than the sum of its parts.

But why should an individual cell specialize in a way that seems counter to its own best interest? Because the colony as a whole is more suited to survive and reproduce so its capacity for passing genes to future generations is enhanced.

“Trade-off genes in unicellular organisms can be co-opted to be altruistic genes in multi-cellular descendents,” Michod said.

Michod said that the computer simulation has shown the importance of specialization as a crucial step in the evolution of increasingly complex organisms. It shows that initial minor differences in skills can drive the process of specialization.

His next step is confirming these theoretical results experimentally with colonies of Volvox.

Source: University of Arizona in Tucson