The Evolution of Sex

Birds do it, bees do it, people do it—in fact the vast majority of organisms do it—but sexual reproduction often seems more trouble than it's worth. For organisms, sex often means spending huge amounts of energy finding and wooing desirable partners. Within the cell, male and female genomes must recombine without major mistakes. Gametes must promote compatible fusions while upholding barriers between species. And at each step, the conflicting interests of each sex must be delicately negotiated in order to benefit the species as a whole.

Asexual reproduction—a simple "copy and divide" strategy—at first glance seems both less messy and more efficient. Yet sexual reproduction is by far the dominant mode, which leads researchers to conclude that sex offers some evolutionary advantage. Biologists have been spinning theories about just what that advantage might be for quite some time, but so far there is no single clear answer.

The debate continues energetically, however, as shown in the news stories and review articles in this special section on the evolution of sex. The topic falls into two parts. First, why did sex evolve in the first place and why is it so pervasive in the natural world? And secondly, how do these amazingly complex sexual systems evolve?

The News story by Wuethrich and Article by Barton and Charlesworth address the first of these questions—what makes sex so alluring from an evolutionary standpoint? Barton and Charlesworth conclude that genetic recombination seems to be the key. Indeed, as discussed in both pieces, most theories suggest that sex and recombination remove harmful mutations and allow new combinations of genes to come together, providing more opportunities for improved fitness and offering the flexibility to adapt to new environments. Biologists are finding new ways to test these theories, Wuethrich reports, but proving that they are actually operating in the natural world remains a challenge.

Once sexual reproduction is in place, what cellular and behavioral mechanisms build the system? In their article, Marín and Baker discuss the evolution of genes that dictate the differential development of the sexes. Some of these genes are stable in evolutionary terms while others, particularly the regulatory genes at the top of the developmental cascade, are changing rapidly. The process by which sperm and egg recognize compatible cognates also involves unusually rapid evolution, as discussed in Vacquier's article. The greatest variety seems to be found in the diverse chemoattractants and surface receptors that promote fusion between the right pair of gametes.

As any human knows, complex mating rituals are often a critical part of reproduction. Ryan's article explores the evolution of mating preferences and discusses the effects of receiver bias—or, how beauty is in the eye of the beholder. Both historical effects and expressed female preferences affect the evolution of characteristically male traits.

Although the sexes come together to mate, their evolutionary interests often conflict. Partridge and Hurst's article provides an overview of the often opposing forces driving the evolution of female and male and the molecular expressions of the war between the sexes.

Two News stories explore particular manifestations of this conflict. Morell takes a new look at monogamy, the one mating system where conflict would seem to be at a minimum. Yet recent research has shown that in many species, females once thought to be monogamous bear offspring with different fathers. Even when social bonds are strong, extrapair matings apparently offer evolutionary advantage. And Pennisi reports on one genetic weapon wielded in the battle of the sexes: genomic imprinting, in which genes from one parent are marked for later silencing or disposal. Mammalian researchers argue that imprinting represents a battle over the growth rate of the fetus, and have new data to bolster their case. Thus, a growing body of research demonstrates that in interactions ranging from molecular to social, sexual reproduction thrives in a metastable state, balancing conflict and resolution—and remaining the most effective reproductive strategy available.

–PAMELA HINES AND ELIZABETH CULOTTA

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