# 36,000 sexes – but it's better "à deux"

BY DANIEL SARAGA

## For evolutionary biologists, the existence of males and females is in many ways paradoxical. Where did gender come from, anyway?

"In evolutionary biology, the emergence of gender is still a very puzzling problem," says Lukas Schärer, an expert in the evolution of sexual reproduction at the University of Basel. "We don't really understand sex yet."

The existence of two genders introduces an immediate disadvantage because it reduces by half the probability of meeting a reproductive partner. "Having two genders is not just a bad strategy, it's the worst strategy," says University of Bath (UK) biologist Laurence Hurst, one of the world's top experts in reproductive evolution. With only one sex – or many – we could reproduce with everyone.

Sexual reproduction does have evolutionary advantages (see box), but it does not necessarily require males and females: it is entirely possible for two similar cells to fuse. "It's important to distinguish two steps," explains Hurst. "First, we need to be able to explain the emergence of two types of gametes [reproductive cells] that, although they remain morphologically identical, can join only with each other. A second level is their differentiation into male and female gametes, which are not only distinct but also different." Adds Schärer: "Theories exist, but an unequivocal experimental demonstration is still missing."

### IT'S THE MITOCHONDRIA'S FAULT

In the 1990s, Hurst proposed a rationale for the first step: a single gender would favor potentially damaging mutations. "By fusing, gametes combine not only genetic information in their nuclei but also share their mitochondria [organelles that provide energy to the cell]," says Hurst. "Because these evolve independently of the nucleus, it's not clear whether dominant mitochondria, for example those that reproduced more rapidly than others, were also beneficial to the cell or the individual."

A solution to this problem would be the emergence of two kinds of gametes (called "+" and "-"), only one of which would be able to transmit its mitochondria. The probability of harmful mitochondrial mutations in the cell would thus be reduced. With two types of gametes that could fuse only with each other, only the kinds of mitochondria that would benefit the individual would be propagated – conferring an evolutionary advantage.

"Our hypothesis is supported by observations made in ciliated protozoans," says Hurst. "Those that reproduce through fusion and com-

### The benefits of sex

**The point of mating is simple: to combine genetic material so as to facilitate adaptation. By combining the genes of both parents, sexual reproduction permits a mixing of favorable mutations and a culling of harmful ones. "Experiments with yeasts that were modified to allow asexual reproduction showed that they adapted less quickly to environmental changes," says University of Bath (UK) Professor Laurence Hurst. "We were able to observe that certain heterogamous species [able to use both kinds of reproduction] favored sexual reproduction when experiencing environmental pressure." Once the danger is past, they go back to solitary sex – which is also helpful when it's too difficult to meet a partner.**

bine their mitochondria have two genders. Those that exchange only their nuclei, without sharing their mitochondria, have hundreds of distinct genders. We observe the same phenomenon in fungi; they exchange only their nuclei, and some species have up to 36,000 sexes." Having only two sexes thus acts as a filter for mitochondria.

## The presence of sexes prevents inbreeding

What is sexual reproduction like when there are many genders? "The two partners still must be of different genders," explains Schärer. "On a probability level, a high number of sexes is in many ways similar to an absence of gender because you can reproduce with almost anyone. But having sexes protects the individuals from reproducing with themselves, which is dangerous because it often introduces harmful mutations." The presence of sexes thus prevents inbreeding.

### THE BIRTH OF THE MALE

But why did the + and – eventually differentiate into males and females? In the 1970s biologist Geoff Parker suggested an evolutionary mechanism. Mutations changed the size of reproductive cells, and slowly two types of individuals were selected: (1) those that make lots of little cells with limited value, and (2) those that make big, rare and precious gametes. The first ones – called sperm – could be produced in vast quantities, which increased the chances they would meet. And, thanks to their large size, the second (the eggs) had a better chance of being fertile and could provide a large quantity of nourishment to the zygote (the fused product of sperm and egg), thereby improving its chances of survival. "The evolution of anisogamy [gametes of different sizes] occurred several times in the course of evolution, and in an independent manner," notes Brian Charlesworth, an evolutionary biologist at the University of Edinburgh. "Anisogamy is probably less likely to evolve in smaller species, because the advantages gained by a large zygote play a smaller role," adds Schärer.

The question of differentiation at the individual level still remains. Why do most animals have individuals that are either male or female instead of both? Hermaphrodism is a mixed blessing: it allows for self-fertilization, which, although it alleviates the difficulty of finding a partner, introduces the risks associated with inbreeding. This advantage might be a determining factor for plants, which cannot move to find a partner – and are mostly hermaphrodites. Not so for animals, which are free to go on the prowl for a mate. ■

## Nature's Kama Sutra

From bacteria exchanging genetic material to fungi with thousands of sexes, Mother Nature has no taboos. Simultaneous hermaphrodites like most plants or snails possess both male and female genitalia, and sequential hermaphrodites (found in some plants, fish and crustaceans) change their sex over time.

Heterogamous individuals (social amoeba, micro-crustaceans, algae) can alternate between sexual and asexual modes of reproduction.

Females of some animal species (including Komodo dragons and hammerhead sharks) have been observed to be able to do without males, reproducing by parthenogenesis when finding a partner is too difficult.

Polyploids don't have pairs of chromosomes like most animals, but multiple copies: mole salamanders are all female, with three copies of their chromosomes, and reproduce by "kleptogenesis" – stealing sperm from males of related salamander varieties.

## An evolutionary scandal: 80 million years without sex

Even though the first single-celled organisms like bacteria have always reproduced asexually, "most multicellular asexual organisms evolved from sexual species," says University of Edinburgh professor Brian Charlesworth. "They have not had time to diversify, and are typically recent in origin."

The discovery that bdelloid rotifers, a kind of asexual aquatic invertebrate, have survived some 80 million years was described as "an evolutionary scandal" by biologist John Maynard Smith.

Another particularity of these invertebrates: they hibernate. When faced with environmental pressure, they dry out and go into suspended animation. A Harvard study in 2008 shed some light on the conundrum: when they reawaken, the bdelloids incorporate foreign DNA from their surroundings. Even for asexual creatures, combining genes seems necessary for survival.