

# Stanford Report



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## COASTAL 'NEIGHBORHOODS'

Hopkins Marine Station biologist Mark Denny recorded the forces that ocean waves exert on intertidal organisms at the marine reserve in Pacific Grove. He and Stephen R. Palumbi, professor of biological sciences, presented findings Saturday at the annual meeting of the American Association for the Advancement of Science in Denver suggesting that marine organisms do not travel as far as previously believed and that coastal areas are "chopped up" into small neighborhoods. See story, page 5.

## Gender scientists explore a revolution in evolution

BY STEPHANIE CHASTEEN

**D**arwin may have been wrong about sex. Or at least too narrow minded.

At the annual meeting of the American Association for the Advancement of Science, leading researchers and theorists in the evolution of sexual behavior gathered Monday to present the growing evidence that Darwin's idea of sexual selection requires sweeping revisions.

"I don't have a theory to address it



all by any means," says Stanford biologist Joan Roughgarden, who organized the symposium. "I'm just trying to get the extent of diversity on the table."

Roughgarden presented evidence that gender is not limited to the static male/female binary and that sex can have social as well as reproductive

roles. Robert Warner of the University of California-Santa Barbara spoke about fish that change sex. David Crews of the University of Texas-Austin addressed the tenuous path linking genetic sex to behavior. Patricia Gowaty of the University of Georgia presented a new hypothesis on how animals select their mates. And Paul Vasey of the University of Lethbridge discussed his research on homosexual behavior among female Japanese macaques.

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**Sex**

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**Sex and Darwin**

Darwin's theories of natural selection are well established and generally accepted: "Survival of the fittest" leads to the evolution of a particular species over time, and species evolve from other species.

But a third theory has piggybacked upon the success of these other two: Darwin's theory of sexual selection. Sexual selection explains the evolution of physical and behavioral traits that increase the odds that an animal will reproduce. These same traits do not necessarily help the animal survive, as do naturally selected traits. The male praying mantis, for example, will sacrifice himself for love – the female begins to eat him even as they copulate. He doesn't survive long after finding his mate, but he does pass on his genes.

**"Female choice, I'm pretty sure, has much more to do with managing male power than it does with trying to obtain good genes," Roughgarden said.**

Darwin postulated that females are "coy," mating rarely and choosing their mates carefully, presumably betting their odds on the males with the best genes to contribute to their offspring. For their part, males are "ardent" and promiscuous, and fight amongst themselves for female partners.

Later theories added that males are promiscuous because they have less to lose by making babies – unlike eggs, sperm are plentiful and small. Plus, females usually do most of the work to raise the offspring.

Sexual selection theory helped Darwin explain many traits, especially in males, that otherwise seemed maladaptive. The unwieldy tail on the male peacock, for instance, makes him more vulnerable to predators but more attractive to females.

Many behaviors do not fit sexual selection theory, however.

Says Vasey of his work with Japanese macaques: "I see females competing for males all the time. I see males ignoring females that are desperate to copulate with them."

A great deal of empirical evidence exists that refutes Darwinian sexual selection. It's difficult to tell just how many exceptions there are to the rule because observations may have been skewed by Darwinian biases, says Roughgarden.

"The exceptions are so numerous they cry out for explanation," says

Roughgarden, who has outlined a stunning array of behaviors that don't fit the mold in her upcoming book, *Evolution's Rainbow: Diversity, Gender and Sexuality in Nature and People* (University of California Press, 2003).

**Sex and society**

Roughgarden thinks that a more comprehensive theory of sexuality should take into account social as well as sexual selection. Mating can function to build and manage relationships as well as to procreate.

"Female choice, I'm pretty sure, has much more to do with managing male power than it does with trying to obtain good genes," says Roughgarden.

For instance, anthropologist Sarah Hrdy studied langur monkeys in the 1980s and found that females promiscuously mate with many males. These females are attempting to protect their offspring, hypothesized Hrdy. Dominant male langurs regularly kill babies that aren't their own, so females protect their infants by spreading the possibility of paternity among several males.

Other sexual traits, says Roughgarden, may represent a "market economy" dedicated to trading sexual opportunity for other resources. In many species, some individuals act as helpers to dominant males and reap some rewards in the process. Dominant male waterbucks, for example, establish a territory along a lakeshore and wait for a female to enter. Subordinate, "satellite" waterbucks help to defend the territory, and in turn may mate with a few females and get a shot at inheriting the territory when the dominant male retires. The payoffs for the dominant and satellite waterbucks may balance out in the long run.

Homosexual behavior is common but unexplained by Darwin. Over 300 vertebrates, including monkeys, flamingoes and male sheep, practice homosexual behavior. Homosexuality in some species appears to play a

behavior is an unattainable goal," says Vasey, one of the leading researchers on homosexual behavior.

In female Japanese macaques, homosexual behavior appears to have evolved from female strategies to coerce reticent males to mate with them. Eager females will mount unwilling males and prompt them to mate with them – a strategy that was easily expanded to mounting other females. Despite these evolutionary origins, however, homosexual behavior among Japanese macaques may have no adaptive value – just as our tailbone evolved but is no longer useful.

This finding is important because it suggests that sex may have functions other than procreation – a healthy ecosystem sports diversity for diversity's sake.

**Beyond male and female**

While two types of sex cells exist – sperm and eggs – it is more difficult to sort individuals into these binary classes. Several species have more than just male and female genders, where gender is defined as the body and sexual behavior of an individual.

In some species, an individual's body may be difficult to classify as male or female. Most plants and some fish are hermaphrodites – capable of producing eggs and sperm. Some lizards are unisexual. There are no male whip tail lizards, and females will mount each other, prompting hormonal changes that result in cell division – a true "virgin birth."

A single individual also may switch from male to female or vice versa and back again – that is, may switch from producing sperm to producing eggs – due to a change in hormones triggered by external circumstances. In any coral reef, for example, about 25 percent of the fish have changed sex in their lifetime. Over 50 species of angelfish, wrasses, parrot fishes and groupers have changed from male to female or vice versa. Other invertibrates, such as



**Joan Roughgarden**  
parental male are mating.

**So you say you want a revolution?**

"The whole context for Darwin's theory of sexual selection is dissolving," says Roughgarden. "So, Darwin is incorrect in the particulars, but more importantly, [his theory of sexual selection] is inadequate even as an approach."

Both Roughgarden and Gowaty think it's time for a revolution, but not every-one agrees.

"This may be better viewed as a refinement of Darwinian theory, rather than a revolution," says Warner.

Vasey agrees, however, that something has to give: "What I'm seeing, in my one species [macaques], is an unbelievable amount of sexual diversity that is very common. I see it every day, and traditional evolutionary theories for sexual behavior are inadequate and impoverished to account for what is going on."

What conclusions can we draw about gender and sexual diversity in humans from such findings? Both Vasey and Roughgarden caution strongly against extrapolating animal behavior to humans, as evolutionary psychologists have done for decades.

"People often look to animals to decide for themselves what's natural and what's

**Vasey and Roughgarden caution strongly against extrapolating animal behavior to humans, as evolutionary psychologists have done for decades.**



**More than one-quarter of all coral reef fish, like this parrot fish, can change from male to female, or vice versa.**

social role. For instance, bonobos (pygmy chimpanzees) will have sex with same-sex partners to calm tensions after a squabble, or to make sure that a large amount of food is shared.

But for some species, humans included, homosexual behavior may have no adaptive value at all.

"Looking for any single conceptual framework to explain homosexual

shrimp and oysters, also may change sex.

"Gender can be surprisingly labile," says Bob Warner, who was among the first to study sex-changing fish in the 1970s. "The young themselves may develop as one sex or the other, depending on the environment in which they find themselves. And individuals may function first as one sex, then another, over the course of their lives, and the change can be socially controlled."

For instance, if the sole male is removed from a group of cleaning wrasse, the largest female will start to behave like a male within hours. Within 10 days she – now he – will produce sperm.

Behavior is not tied to one's chromosomes, either – many species have three or more genders. For instance, bluegill sunfish have two different male genders – "parental" males who control territory and mate with females, and "end-runner" males, who are smaller with different coloring. End-runners will dart in and release sperm where a female and

not natural," says Vasey. "I don't think that's necessarily a good thing to do. I mean, animals engage in cannibalism and infanticide. They also don't take care of elderly individuals. Just because animals do something doesn't make it right or wrong."

Still, a revolution in the biology of sex relates to our perceptions of ourselves – and our sexual politics. People, like fish, can change sex mid-life – the method is surgical, but the expression is one of gender identity. We also have a variety of sexual orientations – straight, lesbian, gay and bisexual. There are men who dress like women, women who dress like men, hermaphrodites born with both sex organs, and others with sex chromosomes that seem to have played musical chairs, resulting in such variations as XXX, XXY and XXYY. Biology is destiny, but biology is diverse.

"This type of research [makes] us reflect on the categories that we use to describe nature and that we use to describe each other," says Roughgarden. ■

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**Male desert big horn sheep are among 300 species of vertebrates that practice homosexuality.**