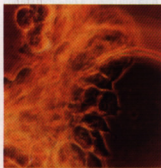




*Spirit* in a phone interview, explaining that by turning off individual genes one by one, scientists can observe the resulting overall effect and likely learn what functions were regulated by that particular gene. "Our main interest is applying this methodology to the study of cancer cells. Which genes can we reverse the expression—or take away—that results in the cancer cells dying or reverting to normal?"



Doctors are hopeful they will soon learn how to make a cancer cell normal again.

The initial test phase will involve the screening of some 300 individual genes, Downward said. A secondary phase is slated to encompass 8,000 more and, assuming all goes well, he's hopeful they can eventually work through the entire human genome.

"With previous methodologies we were having low levels of success," Downward said, estimating it took a single scientist 'years' to successfully inhibit the expression of a single gene before the RNAi process. "With this method, a single person in a lab can do this to 100 individual genes in a week ... but it's not going to be a picnic."

—MK

### Bait and Switch

**a** scuba diver off the coast of Hawaii marvels at the rainbow of coral reef fish surrounding her—yellow tang, silvery smooth wrasse, and flame angelfish the color of a sunrise. Yet there is even more diversity in the water than the stunning array of flickering colors—about one quarter of the fish that she sees have changed from male to female, or vice versa, at some point in their lives.

Citing such examples as sex-changing fish, homosexual behavior among more than 300 vertebrates, and promiscuous female birds, many evolutionary biologists are clamoring for a change in theories of how sexual and

behavioral traits evolved. At February's annual meeting of the American Association for the Advancement of Science (AAAS)—the largest interdisciplinary scientific meeting in the world—Stanford biologist Joan Roughgarden and four other scientists presented accumulating evidence that Darwin's theories require sweeping revision.

In particular, evidence is mounting that neither males nor females act in distinct and prescribed ways, as claimed by Darwin's theory of sexual selection.

"Bodies (and) behaviors don't sort into binary categories," says Roughgarden. "Species may have two sexes but more than two genders."

Darwin's theories of natural selection provided biologists with a good explanation for the evolution of traits over time, favoring 'survival of the fittest.' But natural selection doesn't explain the unwieldy characteristics often shown by males, such

as the beautiful but cumbersome peacock's tail.

To solve this problem, Darwin quietly made the revolutionary claim that females essentially bred such characteristics into males. Because females prefer certain types of males—the bullfrog with the loudest voice, the bowerbird with the prettiest bower, or the peacock with the fanciest tail—this acts as a selection pressure on males of the species. This is called sexual selection.

Research casts doubt on Darwin's claims that certain essential sexual behaviors distinguish between the sexes. In particular, Darwin postulated that promiscuous males compete amongst themselves for females who are reluctant to mate. But in the ten years he has spent studying Japanese macaques, a type of monkey that lives in the snowy mountains near Kyoto, researcher Paul Vasey has compiled evidence to the contrary.



### The Human Ozone Layer

The human body makes ozone. The same stuff that protects us from harmful rays as a component of the ozone layer and presents a respiratory hazard as smog on hazy summer days may well be a factor in fighting disease. According to scientists at The Scripps Research Institute, the gas is produced through a biological process and likely plays a role in protecting us from bacteria and fungi.

The researchers found that during an immune response, human immune cells, called neutrophils, produce a rare form of oxygen used by antibodies to create the ozone—adding yet

another weapon to the attack on bacteria and fungi. The presence of ozone in the human body also appears to be linked to inflammation, leading the scientists to believe there may be significant consequences in treating inflammatory diseases down the road. "This is really something new, and there are a million questions [that follow]," said TSRI Professor Bernard Babior, co-author of the report printed in the March 18 issue of *Proceedings of the National Academy of Sciences*. "What does the ozone do to the body's proteins and nucleic acids? Can neutrophils make ozone without the antibodies? Is ozone made by other cells? How long does ozone last in the body? And, most importantly, how will these discoveries help to cure disease?"—MK



"I see females competing for males all the time," he says, "And I see males ignoring females that are desperate to copulate with them." Vasey adds that he has also observed female macaques actively seeking out other females as sexual partners.

If the sexes aren't simply distinguishable by behavior, can't we at least classify an individual as male or female based upon whether it produces eggs or sperm? Not necessarily. Some species are asexual, unisexual, hermaphroditic, or have up to five distinct genders. Sex is surprisingly flexible in fish, says marine biologist Robert Warner, who was among the first to study sex-changing fish twenty years ago. Half of the known species of coral fish may develop as male or female, change sex during the course of their lives, or pursue mates in different ways, depending upon what works best for them at the time.

For example, if the only male is removed from a group of cleaning wrasse—a coral reef fish—then the largest female undergoes a remarkable transformation. Within hours her behavior changes, and within days she becomes a *he*—a full-



critical mass  
dispatches

### Don't Believe the Hype

AI has a PR problem. It always has. Prophetic statements by researchers, surrounded by press eager to view the debut of a new robotic creature, fall onto the fertile field of sound bites. Fellow scientists sensitive to their field's long-standing problem with hype can only cringe. Robots, those suggestively human manifestations of fundamental work in Artificial Intelligence, have never fulfilled the promise of truly independent and intelligent behavior.

The problem is really one of scope. A strategy is emerging, however, that may reduce skepticism and still create marvel. Recent developments indicate a long overdue narrowing of focus. The emphasis is now on limited utility—

doing something simple, and doing it well. R2D2 will remain science fiction for now.

Navigation is one example. Although simple in purpose, it is quite difficult in practice. Robotic 'rovers' have already been used to explore Mars. This spring, NASA will launch new Mars Rovers. These 'red rovers' are outfitted with mini-science stations and are capable of smartly navigating the landscape. Work is now being conducted by researchers at Carnegie Mellon University to fine-tune the navigational prowess of robots on the simulated Mars terrain of the Atacama Desert in Chile. This will enable future 'spider-bots' to better perform their singular mobility task on the real Mars surface.

How soon will the Earth be crawling with similar single-minded robots doing the mundane to the dangerous? Never mind ... to answer that may lead to hype.—Paul Nye

functioning male that can produce sperm.

Roughgarden also suggests that some sexual behaviors fulfill social functions that cannot be explained by Darwinian sexual selection theory. For instance, homosexuality among bonobos, a type of ape, appears to have evolved to help ease group tensions.

Even the human brain could be explained as a socially selected trait, says Roughgarden. She believes that our large brains give us

the group membership necessary for survival. This proposal is in stark contrast to the work of evolutionary psychologist Geoffrey Miller [*Science & Spirit*, September–October, 2002] who views the human brain as a product of sexual selection. Miller argues that brains evolved because females found smart men attractive, taking IQ as an indicator of good genes, thus creating selection pressure for the evolution of large brains.

While we can't be sure who is right, it would seem traditional Darwinian sexual selection is insufficient to explain the array of sexual behaviors in nature—it must either be discarded or broadened. While it does a good job with showy males like peacocks, it fails to explain the social function of sex or the sometimes-fuzzy lines between male and female.

For Roughgarden, these new ideas about evolution represent a fundamental shift in how we view biology and gender—she believes the weight of evidence has tipped the scales against long-held views of gender and sexuality. "Darwin is incorrect in the particulars, but more importantly, [his theory] is inadequate even as an approach," she says.

Miller, and others, disagree with Roughgarden's dramatic approach: "What's happening is a very exciting refinement of Darwinian theory concerning sexual selection, by no means an overthrow of it," says Miller. "Every good evolutionary biologist working on sexual selection theory is working to extend [Darwin's] insights in new directions—without throwing the baby out with the bathwater."

—Stephanie Chasteen



Gender-bending fish, such as flame angelfish (above), have spurred renewed debate over Darwin's theory of sexual selection.