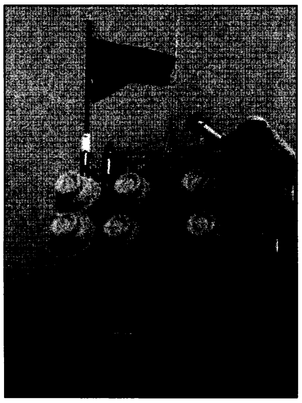
community, all of which required assessment of oxygen consumption in different enclosures for 1 to 6 days (*1*). Remarkable among these technologies is a new benthic research vehicle called ROVER (see the photograph). This autonomous undersea vehicle resembles a small, tracked forklift. It carries a suite of instruments and cameras, a navigation system, and a programmable control system with a limited decision-making capability. ROVER's endurance allows for 6-month deployments, but unlike its relative, Mars Sojourner, it can operate independently of real-time human control for its entire mission.



There is an important temporal aspect to this story with future implications for the stability of benthic communities. In the Northeastern Pacific, the past few decades have seen an increase in sea-surface temperature with a concomitant decrease in primary production and zooplankton abundance (*7–9*). These trends are linked to decreases in the abundance of seabirds and kelp production off the southern California coast (*10, 11*) and are now joined by Smith and Kaufmann's measurements of decreased particulate organic flux in the deep sea during the 1990s.

What are the causes of these regional changes in water temperature, biology, and the supply of food to the deep sea? Is it a natural pattern, or is it partly related to human-induced increases in greenhouse gases in the atmosphere? We cannot yet answer this question, and Smith and Kaufmann leave it as a tantalizing tidbit for us to ruminate over. For the future, it will be important to determine whether these findings in the Northeastern Pacific are applicable to the other oceans of the world. Sayles *et al.* (*12*) showed that benthic community oxygen demand did not vary with the seasons in the Sargasso Sea (of the North Atlantic) and was constant from 1987 to 1993; these results are in contrast to Smith and Kaufmann's clearly seasonal data (particle flux and oxygen demand were highest in early summer and fall, and lowest in winter).

The findings of Smith and Kaufmann will have far-reaching implications for oceanographers, biogeochemists, and climate modelers. We used to think of the deep sea as a highly stable, steady-state system, but with the advent of high-resolution, time-series data sets this picture is changing. Seasonal, annual, and decadal variability in mixing processes and exchanges with other systems appear to be the rule, not the exception. The ramifications of a declining food supply for benthic communities are a sine qua non for future studies of the oceanic carbon cycle.

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NOTA BENE: EVOLUTIONARY BIOLOGY

The Male's Dilemma

What is the cost of male sexual swagger? Exaggerated sexual traits, such as the peacock's tail or the bright coloration of guppies and sticklebacks, lack any obvious survival value. Indeed, these displays of vigor that help the female discriminate between suitors may drain the male's resources. But is there a still greater cost? Folstad and Karter (*1*) have proposed that sexual ornamentation comes at the expense of immune function, increasing the risk of infection and disease. Is there any evidence for this trade off? A recent study by Verhulst *et al.* suggests that there is (*2*).

In a unique set of experiments, these investigators established lines of domestic chickens (*Gallus domesticus*) bred for high or low antibody responsiveness to injected sheep red blood cells. After 15 generations of selection, specific antibodies could not be detected in the low-responder line but were greatly enhanced (compared with control chickens) in the high-responder line. Although this may seem like a bizarre trait on which to base selection, the titer of antibody to sheep erythrocytes is a good surrogate marker of humoral immune responsiveness. The authors compared the size of the sexual ornament—the fleshy serrated outgrowth that crowns the head, called the comb—in high and low responder male chickens. In support of Folstad and Karter's "immunocompetence handicap" hypothesis, they found that low-responder male chickens had larger combs than high responders. (The low-responder chickens themselves were also larger, but comb-size differences persisted after controlling for body size.)

How might ornamentation and immune function be linked? The authors suggest that there might be energy-based competition, with both the heat loss through the comb and the effort required to maintain a constantly replenishing immune system draining energy resources. However, the energy costs involved in setting up and maintaining a sophisticated immune system have not yet been studied in detail.

Another explanation implicates testosterone, which is known to strongly influence comb size. In the Verhulst study, levels of this male hormone varied with anti-sheep erythrocyte antibody titer: high testosterone, low antibody; low testosterone, high antibody. However, the link between the three traits is not as straightforward as it might appear. Exogenous administration of testosterone to birds is not immunosuppressive (*3*) and male birds, which have more testosterone, are not more prone to infection than females (*4*). One intriguing possibility is that immune status modulates testosterone levels (rather than the other way around), which in turn influence sexual ornamentation. Clearly, there is a lot still to be learned about the interface between evolutionary biology, physiology, and immunity.

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