tists that the spacing between the bells that rang as the balls descended past them looked fairly uniform. They should have been placed to demonstrate the dependence on the square of time that is necessary to provide the steady beat of the tinkling provided by the orchestra. (Interviews that Glass and Zimmerman have given show both were aware of the effect of uniform sounds, having run into it at the Museum of the History of Science in Florence.) Would that C. P. Snow's cultures of science and the humanities respected each other by avoiding such minor errors. Glass, indeed, has himself decried the "schism between scientists and artists."

Similarly, the disruptions in chronology that the opera uses to fit in Galileo's physics experiments were bothersome to those knowledgeable about his life. After watching the Cardinal in his garden give Galileo a letter of support (which we have already seen rejected by the Inquisition), we jump to a young Galileo (*4*) and his daughter in church noticing (and timing with a pulse) the constant period of the pendulum traced out by swinging lamps. That observation is something from 1581, almost 30 years before Galileo's telescope work, which appears in the next scene. There we see Galileo, in a stately home presenting one of his telescopes on a stand (which has been at stage right throughout the opera) to three aristocratic or royal women. Oh, for the aria of a soprano at this point!

In the epilogue (which joins the inclined-plane scene as one of the opera's delightful musical highlights), one of the duchesses and Galileo remember themselves as children. The boy (the third actor to play Galileo) and the child who would become the duchess sit on the floor and watch a performance of a fictitious opera by Galileo's father, Vincenzo. A giant moon—though not one of the images Galileo later drew through his telescopes—forms the backdrop behind the stately home. Vincenzo's supposed opera tells the story of Orion, known for hunting the Pleiades and still a hunter as a constellation in the sky, and Merope, now in the sky as one of the Pleiades. The theme of blindness reappears, as Orion is blinded by Merope's father and later healed by the goddess of the dawn. (Zimmerman is well versed in mythology; her version of Ovid's *Metamorphoses* is a long-running success in Manhattan.) The music at this point brought to my mind a circus melody. The joy of the background performance, and the recreation of what Vincenzo's music might have sounded like, made the production deeply pleasurable. Indeed, the trend from unhappy, ancient Galileo to happy, young Galileo is reported to be a major reason for the adoption of the opera's reverse chronology.

Touchingly, the child Galileo rolls up his program to view his father's opera as through a spyglass, foreshadowing the shape and narrow field of view of a telescope (though not, of course, its magnification or its telescoping). We realize that we have been watching the musings of an elderly man looking back on his life. As the opera ends, 95 minutes after it began (with no intermission), we see all the Galileos on stage together. Maria Celeste appears with wings to bring her father to heaven, and all three Galileos follow. The final singing tells about Orion's restoration of sight as he is being made a god in the sky. And we the audience make the inference that the words apply as well to the blind astronomer. (It is moving to think of the elderly Galileo having his sight restored.) In this view, Galileo's apotheosis into the classical pantheon takes place despite his run-in with the Roman Catholic Church.

The story of Galileo retains a resonance for our times. It was retold on PBS's *NOVA* a few weeks after the opera played in New York, in a version openly based on Sobel's book.

Even though the opera's theme is blindness versus seeing, or darkness versus light, and the telescope was on stage throughout, little was made of Galileo's astronomical discoveries. I would have thought them more suitable than the inclined plane and pendulum research that we did see. In addition, the astronomical work has stood the test of time better than some of the arguments Galileo used in the *Dialogo*, and it provided the valid arguments for the Copernican view of the solar system on which we still rely. Albert van Helden's translation of and introduction and notes to *Sidereus Nuncius* (*5*), show the power of Galileo's ideas about astronomy. In this succinct 1610 book, Galileo reports his discoveries of the mountains and maria on the Moon, of the many stars in the Pleiades and Orion, and, most importantly, of the moons of Jupiter; his account should be read by all.

Perhaps we are such a visual culture that even in an opera the music is not especially important. It is Zimmerman's conception and libretto (structured around Glass's idea of the reverse chronology), and the wonderful sets and costumes, that we remember and that make *Galileo Galilei* worthwhile for most of us. Anyone who reads this magazine should certainly try to see this operatic drama when next it is mounted.

References and Notes

1. A. Kozinn, "A Heretical Astronomer Rethinking His Revolution," *New York Times*, 3 October 2002, p. B1.
2. Galileo's works are available in facsimile as well as in rare-book libraries. A beautiful recent edition of *Dialogo sopra i due massimi sistemi del mondo* (Leo S. Olschki, Florence, Italy, 1999) is especially interesting because it includes the marginalia in Galileo's own hand from a copy held by the Biblioteca del Seminario of Padua. The book opens with Stefano della Bella's famous frontispiece that portrays Aristotle, Ptolemy, and Copernicus (drawn with Galileo's face) standing together.
3. D. Sobel, *Galileo's Daughter* (Walker, New York, 1999).
4. Though a professor, Galileo is dressed in ordinary clothes. Even at this early age, his contrariness is apparent, as he ignored laws requiring that he wear the traditional academic gown at all times, on pain of heavy fines. He voiced his objections in a long, satiric poem (1590), which the Italian astrophysicist Giovanni Bignami recently translated and published in a limited edition as *Against the Donning of the Gown* (Moon Books, Milan, 2000); see www.galileounaluna.com.
5. G. Galilei, *Sidereus Nuncius, or The Sidereal Messenger*, A. van Helden, Transl. (Univ. of Chicago Press, Chicago, 1989).

BOOKS: ECOLOGY

It's a Dog's Life

Tim Caro

African wild dogs (*Lycaon pictus*) resemble domestic dogs in appearance, live in packs, hunt large ungulates, are difficult to find, and are highly endangered. All of which make them extraordinarily attractive to tourists visiting Africa, the public in the Western world, and an increasing number of Africans. No wonder there is a raft of popular books about them. Only now, however, do we have the first real scientific treatise on the species. *The African Wild Dog* is jammed full of theoretical background, empirical data, and synthetic discussion by two authors eminently qualified to rise to such a challenge; Scott and Nancy Creel have already published over 20 scientific papers on their subject.

The African Wild Dog
Behavior, Ecology, and Conservation
by Scott Creel and Nancy Marusha Creel
Princeton University Press, Princeton, NJ, 2002. 355 pp. $90, £62.00. ISBN 0-691-01655-0. Paper, $45, £29.95. ISBN 0-691-01654-2.

Focused on 366 wild dogs in 11 packs that inhabit 2600 square kilometers in the northern part of the Selous Game Reserve in southeastern Tanzania, the book is based on field observations gathered between 1991 and 1997. I visited the Selous twice during the Creels's study. The area is extraordinarily tough to work in: steep banks

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next to sand rivers impede driving, thorny vegetation makes tire punctures an almost daily occurrence, thick bush frustrates observations, and there are unpleasant surprise encounters with elephants as well as a constant bombardment of tsetse flies. Brushing such difficulties aside, the Creels collected detailed quantitative data on demography and dispersal, behavior (including cooperative hunting, reproductive suppression, and ranging), endocrinology and disease, the ecology of prey and competitors, and antipredator strategies of the wild dog's principal prey species. Fusing these varied perspectives, the authors conclude that lions (*Panthera leo*) and spotted hyenas (*Crocuta crocuta*) affect many aspects of dog behavior and drive population sizes of African wild dogs throughout their geographic range.

Full-speed chase. When wildebeest form a defensive circle, wild dogs attack simultaneously from several directions. If a few prey then begin to run, the herd often bolts and the ensuing chase reaches speeds of 40 to 60 kilometers per hour.

Several factors have led to the emergence of interspecific competition among carnivores as a prominent theme in conservation biology: The incidence of carnivore species competing for the same resources, forcing one another off carcasses, and killing—and even consuming—each other has been documented for endangered species in several ecosystems. Populations of middle-sized carnivores (called mesopredators) such as cheetahs (*Acinonyx jubatus*) appear limited by larger carnivores. And the elimination of large carnivores by people has led to mesopredator release with subsequent detrimental effects on lower trophic levels. Wild dogs are a classic victim species in predation among carnivores. They fall prey to lions and suffer competition over carcasses from spotted hyenas, which in some ecosystems trail dog packs for months on end. Indeed, the Creels argue that wild dogs' immense home ranges are an adaptation to avoid encounters with these larger predators. For once, the immediate conservation problem is not anthropogenic in nature even though the packs' ranges may take them outside the boundaries of protected areas. Rather, interspecific competition has probably been operating over an evolutionary time scale. For example, cheetahs and wild dogs have extremely large litters, perhaps to mitigate the effects of predation on young. A possible conservation solution—protection of the dogs in areas where large carnivores are absent—seems impractical, however, and the Creels do not explore this or alternative options in any depth. Indeed, despite its subtitle, the book is slanted far more towards behavior and ecology than conservation. But this may be excusable, given that a comprehensive survey of the African wild dog's status and plan for its conservation was published in 1997 (*1*).

I particularly liked a chapter using hitherto untapped data on the strategies wildebeest (*Connochaetes taurinus*) and impala (*Aepyceros melampus*), the principal prey of large and small dog packs respectively, use to avoid predation. Here the authors examine separately four effects through which herd size influences predation risk: the probability of being encountered by dogs, the chance of being attacked once seen, the likelihood of the predator making a kill, and the dilution of risk (the probability an individual will be the victim given that a kill will be made). Herd size affects these probabilities in different ways, and combining them together produces an impressively well-rounded picture of the antipredator benefits that grouping provides. For impala, the combined probabilities of encounter, hunting, killing, and dilution mean individuals in large herds face a lower overall risk of predation. For wildebeest, however, the combined risk is lower for individuals in small herds. In neither case is early detection of dogs a likely benefit of group size, as it is in so many bird species, because coursing predators do not rely on stealth to get near prey but instead test for vulnerable prey individuals by inducing herds to flee. This analysis is the first time I have seen data on encounter risk being incorporated into calculations of the antipredator benefits of group size.

In short, *The African Wild Dog* is a book about a species that is inherently fascinating for a wide variety of reasons. The authors demonstrate how different sorts of data can be collected simultaneously even under difficult field conditions, and they then bring state-of-the-art quantitative analyses to bear on theoretical issues of current interest. As a consequence, the book moves our understanding—in particular, of reproductive suppression, cooperative hunting, and intraspecific competition—forward in a compelling way. The work is behavioral ecology at its best.

Reference

1. R. Woodroffe, J. R. Ginsberg, D. W. Macdonald, the IUCN/SSC Canid Specialist Group, *The African Wild Dog—Status Survey and Conservation Action Plan* [IUCN (World Conservation Union), Gland, Switzerland, 1997]. Available at www.canids.org

BROWSINGS

Wild Cats of the World. *Mel Sunquist and Fiona Sunquist*. University of Chicago Press, Chicago, 2002. 461 pp. $45, £28.50. ISBN 0-226-77999-8. Cat lovers and researchers alike will find much of interest in this comprehensive reference. The Sunquists have gathered information from scientific journals, historic documents, and the gray literature (unpublished theses, reports, newsletters, and personal communications) as well as their own field work around the world. For each of the 36 extant species of wild felids, they provide a description, detailed data on ecology and behavior, and summaries of the distribution, status in the wild and captivity, and conservation efforts. The African wildcat *(Felis silvestris lybica)* is the likely progenitor of domestic cats. Its long legs and short, close fur (above) distinguish it from the conspecific European wildcat *(F. s. silvestris)*.