Vignettes: Innovation Management

The American legal system's adjustment to the industrial revolution suggests that it will adjust to the technological revolutions that lie ahead. Thus we see again the contrast between the scientists' sense of a world making progress and the lawyers' sense of a more or less endless process of mediating social disputes. J. D. Watson exuberantly described his pathbreaking work in formulating the double helix model for DNA as "perhaps the most famous event in biology since Darwin's book." Yet in an early discussion of legal controls on recombinant DNA research, the prominent attorney and legal scholar Harold Green reported that he was "happy to say" that nothing "unique or novel" in such research insulated it from regulation.

—*Steven Goldberg*, in *Culture Clash: Law and Science in America* (New York University Press)

What are the duties of the inventor to his invention? To what extent must the inventor be responsible for seeing that his new invention and the world into which it is brought are compatible? Frankenstein's creation, while offering to do his duty to the doctor if the doctor will only fulfill his obligations and care for him, is nevertheless ready to exact revenge if the doctor does not. The monster's murder of Frankenstein's bride on their wedding night must be set against Frankenstein's refusal to make a companion for the monster, a refusal to help fashion an appropriate environment for his invention.

—*Cary Fowler*, in *Unnatural Selection: Technology, Politics, and Plant Evolution* (Gordon and Breach)

tative (and, it is fair to say, extremely vague) proposals. He claims that including the effects of gravity within the quantum-mechanical formalism will make a qualitative change in its predictions for the behavior of macroscopic bodies, in such a way that the laws of classical probability will apply for sufficiently large bodies. Well: what about the behavior of K-mesons, neutrons, and even photons, which are known by exquisite interferometric experiments to maintain quantum coherence after traversing what are by any reasonable measure macroscopic distances? What about superconductors, which conduct perfectly "through a mile of dirty wire" (Casimir), or similarly superfluid helium? What about the profound and beautiful work now being done on mesoscopic systems, which probes quantitatively how characteristic quantum mechanical behavior gradually becomes more subtle—but does not seem to break down or disappear—for pure, small, cold but definitely macroscopic systems (involving many thousands of electrons)?

The quantum theory of gravity is fraught with difficulties regarding its behavior at high energies and short distances, difficulties that may or may not be resolved by superstring theory. However, quantization of the low-energy, long-wavelength part of the Einstein theory is not problematic, and effects of the sort Penrose proposes ought to be discussed within this theoretical framework, as a first step. My own tentative conclusion is that the predicted effects are exceedingly small and are likely to be overwhelmed, under any remotely practical circumstances, by more mundane processes. In any case this framework is eminently *computable*, in the technical Turing-machine sense, so it is not sufficient for Penrose, who wants somehow to introduce a *noncomputable* R-process.

For the next step in Penrose's synthesis is to invoke the hypothetical noncomputable R-process to explain the supposed noncomputable abilities of human brains. Regarding this, I (like Penrose) will be brief. He claims, inspired in part by ideas of Hameroff, that microtubules perform crucial information-processing roles in the human brain and that they behave in essentially quantum-mechanical ways that allow them to transcend the limitations of Turing machines. A lot is known about information processing in the brain, particularly in the early stages of visual processing, and as far as I know it has never proved necessary to assign an important role to microtubules. Microtubules are not particularly characteristic of the human nervous system—indeed they are common in single-cell organisms—and on the face of it appear to be versatile structural elements in many classes of cells. Moreover, the conditions of heterogeneity and temperature characteristic of biological activity hardly seem conducive to quantum coherence on a macroscopic scale. So speculations about a spectacular computational ability of microtubules based on quantum coherence and central to human consciousness appear quite bold at this time. They, at least, would seem to be open to experimental investigation in the near future.

It appears to me, in summary, that Penrose's argument, from formal logic and philosophy, that human beings perform noncomputable operations is simply mistaken; that his argument that quantum theory is incomplete is unconvincing and his proposed remedy implausible; that his conclusion that an essentially classical description of microtubule function must fail is premature to say the least; and that his discussion of this topic, and of neurobiology in general, does not do justice to a large important body of relevant empirical knowledge. Moreover, the whole grand structure of his arguments is exceedingly fragile, being at no point buttressed by specific reference to nontrivial experimental facts. Perhaps not since the heyday of the great rationalist metaphysicians—Descartes, Leibniz, Spinoza—has there been a comparable performance. Although there are several brilliant passages in the book and the distinguished author is evidently sincere in his convictions, in the end one can only agree with Francis Crick, who wrote (commenting on *The Emperor's New Mind*), "It will be remarkable if his main idea turns out to be true."

Frank Wilczek
Institute for Advanced Study, Princeton, NJ 08540, USA

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Cats in Groups

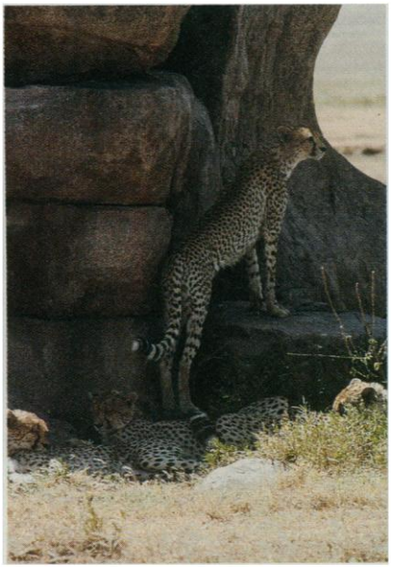
Cheetahs of the Serengeti Plains. Group Living in an Asocial Species. T. M. CARO. University of Chicago Press, Chicago, 1994. xxii, 478 pp., illus. $70 or £55.95; paper, $26.95 or £21.50. Wildlife Behavior and Ecology.

This book continues the tradition of excellent studies of the life histories of individual species that have emanated from the Serengeti, one of the world's most spectacular ecosystems. Apart from providing a synthetic account of the biology of cheetahs in the wild, Caro explores the evolutionary causes of social behavior and examines the behavior of cheetahs from a functional perspective.

This book contains a wealth of valuable and interesting data that have been carefully collected, expertly analyzed, and clearly

presented. The study is a fine example of how to set up and plan a field study of this nature and particularly impressive for the discipline that the author showed in deciding which animals to follow and when in order to obtain enough data from the various combinations of sex-age classes to test most of the hypotheses he constructed. Where the author was unable or failed to collect the necessary data, as is inevitable in a field study, he freely admits it.

Cheetahs, we learn, provide a unique model for investigating the evolution of social systems, as different age-sex classes live alone as well as in groups—they are group-living in an asocial species. Moreover, group formation occurs for different reasons in each age-sex class, as the author eloquently shows. Adult males form permanent coalitions to enhance their competitive edge when contending in areas of high female density, littermates stay together through adolescence to reduce harassment from predators, and females look after their young for an extended 18-month period to further their reproductive success, while their cubs are protected from predators and provided with food.



"Vigilance among sibgroup members. A female scans the surroundings while her three brothers doze in the shade of a kopje during the midday rest period." [From *Cheetahs of the Serengeti Plains*]

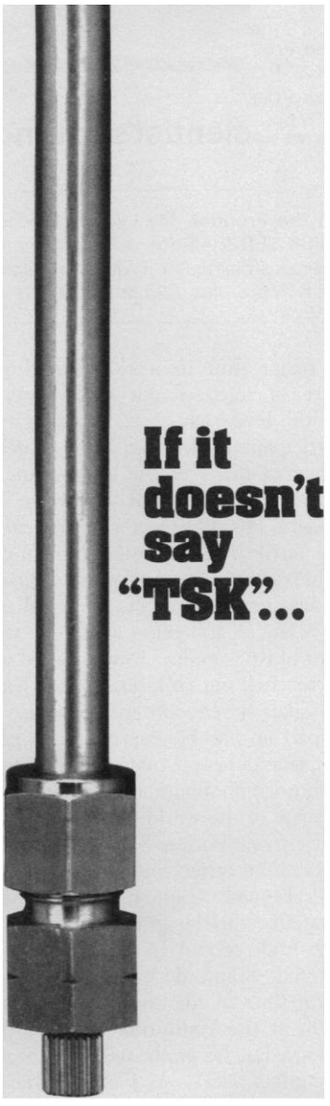
Why is it that among male felids only cheetahs and lions are group-living? Caro argues that these two species are unique in that their females tend to have clumped, albeit rather different, distributions. Lionesses associate and form prides. Cheetah females in true felid tradition are solitary, except when accompanied by cubs, but inhabit vast overlapping home ranges, which in the Serengeti cover on average 833 square kilometers. Within these ranges females aggregate in certain areas for purposes of feeding. Both these female dispersion patterns set up conditions for intense male competition, and the formation of alliances between males is a good way to deal with this problem. Lion males form coalitions that take over a pride. Cheetah male coalitions inhabit small, on average 37.4-square-kilometer, territories in the female aggregation areas. My own cheetah observations in the Kruger National Park, a more wooded area than the Serengeti with a largely sedentary prey population, support Caro's argument, although here the overlapping female ranges and the male coalition territories are similar in size, being about 150 square kilometers.

Although males in coalitions gained greater per capita foraging returns through a tendency to select larger prey, there was little cooperation between them during hunting. In fact, the considerable quantity of data collected during the study deals yet another blow to the original explanation that group living arises as a result of cooperative hunting in mammalian carnivores.

I was very surprised to learn that only 4.8 percent of cheetah cubs born on the Serengeti plains reached independence. The major cause of cub mortality is lion predation. It is hard to believe that this population could be viable, yet the evidence suggests that it is and that it has remained stable over the last 20 years or so. To compensate for this high mortality, cheetahs reach maturity relatively early and have large litter sizes for felids.

What do studies of this nature do for the conservation of the species? Certainly a basic knowledge of life history patterns is fundamental to the setting up of sound management strategies. It is also valid to argue that uncovering the wonderful mysteries of these animals puts the spotlight on them, enhancing their survival chances through increased awareness. However, I must agree with the author's closing remarks: "We already know a great deal about the ecology and behavior of free-living cheetahs, . . . and while detailed studies of individuals in their natural habitat raise new questions about evolution and ecology, they fail to address the conservation of the species head on. Thus for those interested in the long-term future of cheetahs, my advice is to get involved in reintroduction programs or ecological monitoring or enter the world of conservation politics, especially at a local level, rather than fiddling while Rome burns."

M. G. L. Mills
National Parks Board, Skukuza 1350, South Africa



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