Browsings

Emerging Infections. Richard M. Krause, Ed. Academic Press, San Diego, CA, 1998. 527 pp., illus. $84.95. ISBN 0-12-425930-8. Biomedical Research Reports.

After introductory chapters on emerging infectious diseases and the analysis of epidemics, contributors cover the population, evolutionary, and medical biology of new and recurrent bacterial, viral, and parasitic infections including tuberculosis, influenza, dengue, malaria, Hantavirus, Ebola virus, and Lyme disease.

The Gospel of Germs. Men, Women, and the Microbe in American Life. Nancy Tomes. Harvard University Press, Cambridge, MA, 1998. 366 pp., illus. $29.95. ISBN 0-674-35707-8.

Aided by public health reformers and home economists, the findings of late 19th-century bacteriologists were transformed into a popular obsession with germs. Tomes' narrative suggests that the legacies of that earlier phobia still affect infectious disease control today.

Perceiving Talking Faces. From Speech Perception to a Behavioral Principle. Dominic W. Massaro. MIT Press, Cambridge, MA, 1998. 507 pp., illus., with CD-ROM. $55. ISBN 0-262-13337-7.

To consider the bimodal (auditory and visual) processing of speech, the author combines theory, empirical results, and the construction and testing of mathematical models. The talking-head technology used in many of the experiments is described in detail, and the accompanying CD-ROM allows readers to experience the phenomena under consideration.

Science Incarnate. Historical Embodiments of Natural Knowledge. Christopher Lawrence and Steven Shapin, Eds. University of Chicago Press, Chicago, 1998. 350 pp., illus. $55. ISBN 0-226-47012-1. Paper, $19 or £15.25. ISBN 0-226-47014-8.

Through considerations of the habits and practices of individuals (including René Descartes, Isaac Newton, Ada Lovelace, and Charles Darwin), the essays in this collection explore connections between human bodies and our body of knowledge.

Second Nature. Environmental Enrichment for Captive Animals. David J. Sheperdson, Jill D. Mellen, and Michael Hutchins, Eds. Smithsonian Institution Press, Washington, DC, 1998. 370 pp., illus. $32.50. ISBN 1-56098-745-6.

Contributors to this volume explore a range of approaches for addressing the psychological needs of captive animals (primarily mammals, mainly in zoos). By stimulating more diverse natural behaviors, managers can improve the physical well-being of these animals, facilitate breeding and reintroduction efforts, and help educate visitors.

RESEARCH: GAME THEORY

Give and Ye Shall Be Recognized

Claus Wedekind

Students often share a flat because it is too expensive to rent one alone. Later, their flat sharing may include reciprocal shopping, cooking, cleaning, and household chores. Such cooperative behavior can be seen as a form of reciprocal altruism ("I scratch your back, you scratch mine"). Humans, however, are frequently altruistic even if the altruistic act is not likely to be returned by the recipient. In the June 11 issue of *Nature*, Nowak and Sigmund (*1*) explain why such behavior can pay off in the long run and so be evolutionarily stable. According to their main idea, whether an individual helps others determines his or her social status in the group. Indirect reciprocity can evolve if the others take this information into account in future social interactions.

Those with experience in flat sharing know that reciprocal altruism is not the whole story. Unfortunately, it is tempting for each of the occupants to do a little bit less than the others, just as it is tempting for industries to discharge radioactive or chemical wastes into the common instead of using a cleaner but more costly solution, or for fishermen to catch more than their fair share of fish (*2*). Game theory is a branch of mathematics devoted to such problems—to problems of cooperation and conflict in social situations (*3*). This is a broad area. It is in fact difficult to think of any form of social behavior, be it simple or complex, that is neither cooperative nor competitive. The breadth of this problem has kept sociologists, psychologists, economists, and biologists working for decades, using game theory as their basis.

Previous theoretical work suggested that direct reciprocity readily leads to the evolution of cooperation (*4–6*), but only in very small groups (*7*, *8*). Thus, the fact that humans sometimes cooperate in large groups of unrelated individuals has been an evolutionary puzzle. This puzzle may have been caused partly by the way people thought about social dilemmas. Dilemmas have been described mostly as two player or *n*-player matrices. For example, in the two-player "Prisoner's Dilemma" matrix, each player gets more if both cooperate than if both defect, but if one cooperates while the other does not, the cheater gets most and the betrayed least. Played only once, the evolutionary stable strategy for both players is to defect. This way they achieve less than if they had cooperated. If repeated, however, this game usually leads to rather cooperative solutions (*6–10*). In multiplayer Prisoner's Dilemma games the solutions are less cooperative (*7*, *8*).

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Social climbing. Acts of apparent altruism, such as donations to a street musician, may not actually be so selfless if the generous act increases the donor's social status.

There are everyday situations that are not easily approximated by such games. If you meet, for example, a street musician you have two options: either to give some money or not to give anything. Of theoretical interest is that this decision will, in most cases, not have any impact on whether the musician continues to play or not. The situation can be seen as a two-player game in which one party decides whether to lose

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money while the other party does not react to this decision. A similar situation arises with a beggar. The only difference between these two game situations is that the beggar provides nothing other than perhaps a "thanks," whereas the musician provides his or her music. So why can street musicians sometimes earn so much that they are able to take their music on the road and travel around, and why does begging pay enough to support at least some people who beg full time? Is it because many of us are influenced by cultural rules and taboos ("memes") that prompt us to give money (*11*, *12*); or is it because some of us are "bad" players, players of nonadaptive strategies that would disappear rapidly when under strong natural selection?

There is a third possible explanation for this kind of seemingly altruistic behavior, described earlier (*13*, *14*) and now formally proven by Nowak and Sigmund (*1*). This is cooperation by indirect reciprocity. It involves the inclusion of an additional variable to the game—social status. The idea is that being observed giving something to, for example, the street musician increases your social status (see the figure) and that being observed withholding your gift decreases it. Giving something may pay off in the long run if the people you interact with in the future take your social status into account. Giving may not be a real altruistic act—rather, it could be a sophisticated investment into one's own future. Nowak and Sigmund demonstrate that already simple rules about how information on social status is used can lead to cooperation in situations where direct reciprocity is unlikely. They also find that group size is important. For larger groups it is more difficult to establish cooperation, because there are more interactions required to discriminate against defectors. However, cooperation by indirect reciprocity could easily evolve in their models in groups of 20 to 100 individuals, even if the probability of being observed in such interaction varied from 1 to 0.1. This means that if you meet a street musician you are inevitably caught in a game. Whatever you do, it may have an impact on your social status. Even if it is unlikely that none of your future social partners will see or hear about your decision, you can never be sure about this. Moreover, cooperative moves that happened to be observed in apparently anonymous situations are likely to weigh higher on your social status account, but the same may be true for uncooperative moves.

Nowak and Sigmund (*1*) argue that social status is a variable with decisive impact on the evolution of human society, because it binds larger groups of individuals together and makes cooperation on a larger scale possible. Moreover, working on one's own social status and having to deal with the difficulties in continuously readjusting the perceived social status of the many members of a group might have selected for social intelligence and for an ability for abstract thinking in our species. We as human beings have all thought a great deal about the social rules we live under, about right and wrong, and we usually have rather determined opinions. This and our social experience make us intuitive masters of highly sophisticated social games (*9*, *10*). It is funny that we are only now starting to understand the rules that we use in our own games.

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PLANETARY SCIENCE

New Insights on the Kuiper Belt

Alessandro Morbidelli

When Edgeworth and Kuiper first conjectured the existence of a belt of small objects beyond Neptune—now called the Kuiper belt—they were imagining a disk of planetesimals preserving the pristine conditions of the disk of matter that eventually became the planets of the solar system. However, since the first discoveries of Kuiper belt objects, astronomers have realized that it is not pristine: The disk has been affected by a number of processes that altered its original structure that are still not completely understood. On page 2104, Ward and Hahn (*1*) report new results that provide insight into the structure and evolution of this curious planetesimal system.

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The known structure of the Kuiper belt, determined on the basis of the discovery of 64 objects (*2*) in the region beyond Neptune, is summarized in the figure (top and middle panels). In the inner belt [semimajor axis smaller than 40 AU (*3*)], all the known objects have large eccentricities. They are associated with first-order mean motion resonances with Neptune, the only dynamically stable regions at large eccentricity (*4*). Actually, all but one of the objects discovered in the inner Kuiper belt are in the 3:2 resonance—like the "planet" Pluto—and are therefore called Plutinos.

Beyond 42 AU (*5*) begins the "classical" belt, where the discovered objects are not specifically related to any mean motion resonance. Although the eccentricities and inclinations are generally smaller than in the inner belt, once again the classical belt does not look like a proto-planetary disk, because the latter should be made of planetesimals on quasi-circular and coplanar orbits. In particular, a few objects have surprisingly high inclinations, despite the observational biases not favoring their discovery (*6*). This allows one to conclude that some process must have excited eccentricities and inclinations not only in the inner belt but also in the classical belt.

In addition to the inner and the classical Kuiper belts, theoretical considerations (*7*) and the discovery of at least one object (*8*) argue for the existence of a third population of bodies, which evolve under the effects of close encounters with Neptune, forming a sort of scattered disk.

According to the statistics of discoveries per unit area of searched sky, about 70,000 objects bigger than 100 km should exist in the Kuiper belt up to 48 AU (*6*), only 10 to 20% of them being in the inner belt (*9*). The estimate of the total mass of the belt up to 48 AU is still uncertain within one order of magnitude, ranging from 0.06 to 0.3