whose orbitals are each occupied by two electrons. In contrast to the RVB model, any electron vacancies (holes) added by, for example, substituting strontium for lanthanum will end up on the oxygen ions. The presence of a hole on an oxygen ion generates a spin because there is now an odd number of electrons there. The entities that pair to form bosons that can condense into the superconducting state are the electrons on the oxygen ions, but it is more convenient to think in terms of holes.

In the language of quantum field theory as applied to conventional superconductors, the attractive force that pairs electrons arises when the electrons exchange a phonon. The same idea applies in Emery's theory, except that the exchanged quantity is called a spin excitation. Consider a copper ion flanked by two oxygen ions that are occupied by holes with opposite spins. Spin excitation refers to the flipping of the spin on the copper ion when the holes on the oxygen ions exchange their spin. It takes place in two steps. Spins can migrate through a lattice by exchanging sites with a neighboring spin of opposite orientation. First, the copper ion and that oxygen with a spin opposite to the copper exchange spins. Then the copper and the second oxygen exchange spins, returning the copper spin to its original orientation. Unfortunately, there is no simple classical picture of why this exchange causes an attraction between the holes.

Whether pairing of the holes occurs at a higher temperature than condensation of the pairs is directly related to the ratio of the distances between the members of the pair and between pairs. In conventional superconductors, where pairing and condensation occur together, this ratio is large, whereas a small ratio favors pairing before condensation. Although the question remains to be answered by experiment, Emery believes that the ratio of distances in the ceramic oxides is large enough for pairing and condensation to occur together.

All in all, the origin of superconductivity in the ceramic oxides is a very difficult problem for theorists and experimentalists alike. Birgeneau says, "This is the first problem I've encountered in 10 years where you have to know all of solid-state physics to work on it." But everyone agrees that the best way to determine if spin fluctuations really do underlie high-temperature superconductivity in these compounds would be to extend neutron scattering measurements to good quality single crystals of superconductors. This is not a trivial requirement because neutron scattering requires rather large samples, such as the 0.5-cubic-centimeter crystals of La_2CuO_4 grown at NTT.

■ ARTHUR L. ROBINSON

How Big Can a Species Be?

"People will probably accuse us of flogging a dead horse," says John Eadie of the University of British Columbia. "Maybe we are, but we want to flog it until someone smells it." The terminated equine to which Eadie refers is the business of species-size ratios in nature, a phenomenon whose apparent significance held ecologists in its thrall for some 20 years. During the past few years, however, the perceived implication of size ratios—specifically, the importance of competition in communities—came under attack, and promptly withered. "What we have been looking at," says Eadie, "is something that might be even more fundamental."

Working in conjunction with Louis Broekhoven and Patrick Colgan of Queen's University, Ontario, Eadie concludes that the existence of the long-discussed size ratios is the inevitable outcome of the distribution of species' sizes in nature. That distribution—described statistically as lognormal—is like a bell-shape curve in which the right-hand tail is extended. "The interesting question to ask," says Eadie, "is, what underlies the lognormal distribution?"

Species' sizes and the differences between them has long been a subject of concern to ecologists, but it became enshrined in the theory of the subject when, in 1959, Evelyn Hutchinson observed that similar species subsisting at similar trophic levels were separated in size by a ratio close to 1.3. (The size ratio might apply to the body as a whole or to the structure the organism used in making a living, such as beaks in birds.) Hutchinson proposed that competition pushed species apart, and a difference of 1.3 in size represented a boundary at which coexistence was possible. "The notion became so entrenched in the ecological literature that the mere observation of a ratio near 1.3 . . . was often taken as prima facie evidence that communities were organized according to the principles of [competition]," note Eadie and his colleagues.

In fact, when the putative link between size ratios and competition was examined critically—principally at the instigation of Daniel Simberloff, of Florida State University, and his associates—it began to look very tenuous indeed. And, as several authors have pointed out, size ratios of around 1.3 are very common in the world, among objects both animate and inanimate. "Although these criticisms point out the limited utility of size-ratio analyses," note Eadie and his colleagues, "they do not present a mechanism to explain how such artifacts could arise."

The Canadian researchers analyzed a series of 33 ecological studies that encompassed 439 assemblages of species. In 93% of cases the size distribution was most accurately described as lognormal, out of which the 1.3 ratio inevitably falls. (In addition, the variances are small.) "Hutchinson's constant, then, may simply be an inadvertent artifact of a lognormal distribution of animal sizes in nature," they note.

The question then becomes, what governs the original lognormal distribution? "It is not unreasonable to think of a trait such as body size evolving in response to a large number of independent, selective pressures among which competitive ability is only one," suggest Eadie and his colleagues. In other words, when one is dealing with a measure—body size in this case—that is the product of the interaction of a multiplicity of influences, a lognormal distribution inevitably results: and this holds whether you are dealing with canaries or cookie cutters.

Eadie and his colleagues are clearly not saying that the 1.3 Hutchinsonian ratio does not exist, and neither are they suggesting that competition is not sometimes an important component of species assemblages. What they are saying is that competition is just one of many factors that influence the shapes of those communities, that there are other, perhaps more fundamental factors involved. "I'm hoping that people will see beyond the dead horse," notes Eadie. "Maybe there was an important question that we all forgot to ask right at the beginning." ■

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ADDITIONAL READING

J. McA. Eadie *et al.*, "Size ratios and artifacts: Hutchinson's rule revisited," *Am. Nat.* **129**, 1 (1987).