A number of recent theoretical suggestions might point to what we have missed. Theoretical work on insulating two-dimensional magnets has shown (*11*) that under certain circumstances, yet to be realized in a real material but nevertheless entirely plausible, excitations appear at the critical point that bear no resemblance to the fluctuations in the ordered phases. Extending this idea to the metal might suggest that it is the break-up of the electron itself that is being reflected in this new energy scale (*12*).

Alternatively, this new energy scale could be a reflection of the unusual nature of the metallic state in YbRh$_2$Si$_2$, which is a mixture of magnetic atoms like ytterbium bathed in a fluid of metallic electrons. The fate of the spins in materials like these has long been known to lie in the balance between two extremes (*13*). Either the spins form an ordered magnetic state, leaving the conduction electrons alone, or the spins and conduction electrons can fuse to create a metallic state of apparently heavy electrons. Usually it is assumed that this second process happens and is followed by a weak magnetization of the resultant metal. These experiments could suggest that the quantum critical point is not primarily about magnetic order at all but rather is a transition between these two different fates of the spins (*14*) (see the figure). Whatever the underlying cause, the theorists now have a clear task: Unravel the identity of the new energy scale.

References

1. See, for example, P. M. Chaikin and T. C. Lubensky, *Principles of Condensed Matter Physics* (Cambridge Univ. Press, Cambridge, UK, 1995).
2. J. A. Hertz, *Phys. Rev. B* **14**, 1165 (1976).
3. A. J. Millis, *Phys. Rev. B* **48**, 7183 (1993).
4. P. Gegenwart *et al.*, *Science* **315**, 969 (2007).
5. N. D. Mathur *et al.*, *Nature* **394**, 39 (1998).
6. J. Paglione et al., *Phys. Rev. Lett.* **91**, 246405 (2003).
7. P. Coleman, A. J. Schofield, *Nature* **433**, 226 (2005).
8. O. Trovarelli *et al.*, *Phys. Rev. Lett.* **85**, 626 (2000).
9. G. R. Stewart, *Rev. Mod. Phys.* **73**, 797 (2001).
10. G. R. Stewart, *Rev. Mod. Phys.* **78**, 743 (2006).
11. T. Senthil, A. Vishwanath, L. Balents, M. P. A. Fisher, *Science* **303**, 1490 (2004).
12. T. Senthil, *et al.*, *Phys. Rev. B* **69**, 035111 (2004).
13. S. Doniach, *Physica B* **91**, 231 (1977).
14. P. Coleman, *et al.*, *J. Phys.: Condens. Mat.* **13**, R723 (2001).
15. Q. Si, S. Rabello, K. Ingersent, J. L. Smith, *Phys. Rev. B* **68**, 115103 (2003).

10.1126/science.1139335

ANTHROPOLOGY

Some Like It Hot

Studies of novel types of microfossils reveal new patterns and connections between human movement and the distribution and movement of plant species, both domesticated and wild.

Sandra Knapp

Can you imagine some of the great world cuisines—such as Indian, Thai, and Korean—without chili peppers? This fiery spice has become an integral part of cooking and culture far from its native range. Chili peppers (*Capsicum*) come from the Americas and were introduced to places such as India and Thailand after Europeans explored the New World in the 15th century. On page 986 of this issue, Perry *et al.* (*1*) shed light on when and where chili peppers were first cultivated. Data from studies of this kind may also have potential use in the analysis of human transport and spread of invasive species.

Capsicum is a genus comprising about 25 species (*2*). It is a member of the plant family Solanaceae, which contains other economically important plants such as the potato, the tomato, and tobacco. Brazil is the center of species diversity for *Capsicum*, but many species are also found in the Andes. Humans have domesticated and today cultivate five species of *Capsicum*, all for their spicy flavor that comes from the long-chain amide capsaicin. Some varieties of the cultivated species (such as bell peppers) lack high quantities of capsaicin, but the sensation of hotness and the "endorphin rush" induced by eating chilis largely account for their universal appeal.

Capsaicin is a specialized metabolite that is produced in the fruits of some *Capsicum* species as a deterrent to seed predators. Great variation in capsaicin content has been introduced through plant breeding into cultivated species of peppers, but wild species of *Capsicum* also have hot and mild forms (*3*). Humans first exploited this metabolite in the Americas, and European explorers and colonists later transported this and other New World plants all over the world. But exactly when and where domestication of peppers first occurred have proved difficult to establish (*4*), in part due to a lack of macrofossil remains for these tropical plants.

Perry *et al.* now show that peppers were cultivated and in widespread use across the Americas 6000 years ago, not only as occasional condiments, but also as components of a complex and sophisticated diet. The authors recovered microfossils of starch grains from grinding stones and cooking pots in archaeological sites from the Caribbean, Venezuela, and the Andes. They found *Capsicum*-specific starch grains in association with maize and manioc. Their evidence suggests that three of the five species of domesticated *Capsicum* were cultivated together in Peru in both the coast and the highlands as long as 4000 years ago.

As humans moved around all over the face of the Earth, they carried with them their favorite foods and herbal medicines. *Capsicum* is notable in this regard, as it quickly became integral to a wide range of Old World disciplines, from Indian cuisine to Tibetan medicine (*5*). Other members of the Solanaceae, such as thornapple and tobacco, have also had their native distributions obscured by human transport. The scientific name *Datura* was given to the thornapples by Linnaeus from the Sanskrit "dhustura," but all species of *Datura* are in fact only native to the Americas (*6*).

Diversity explained. These different kinds of *Capsicum*, grown at the University of Wageningen (*8*), illustrate the diversity of shape and color in domesticated chili peppers. Perry *et al.* (*1*) show that peppers have been cultivated across the Americas for at least 6000 years.

CREDIT: REPRODUCED WITH PERMISSION FROM (8)

What is a native range when humans transport plants so far from their origins, and alter them through selection to suit their own purposes? Today's concern over invasive species and their threat to native biodiversity (*7*) highlights the importance of understanding how human movements and transport have

---

The author is in the Department of Botany, The Natural History Museum, Cromwell Road, London SW7 5BD, UK. E-mail: s.knapp@nhm.ac.uk

affected distributions of plants and animals. Species of plants introduced for a variety of reasons have come to invade ecosystems in alarming ways: witness Japanese knotweed in Britain or kudzu in the southern United States. Domesticated plants have always been taken by humans wherever they have traveled and are mostly (but not always) unproblematic, but these patterns can be among the most difficult of all distributions to unravel. New ways of studying ancient human use and transport of plants can contribute to our knowledge of the dynamics of introductions, including the effects of invasive species.

Perry *et al.*'s innovative use of starch grains from kitchen tools, coupled with their elegant unraveling of the specificity of these grains to domesticated *Capsicum,* reveals more ancient cultivation and widespread use of this crop plant than previously reported. It also opens up new avenues of research into how the peoples of the Americas transported and traded plants of cultural importance. The authors found no starch grains of wild species of *Capsicum* in any of the sites they examined, showing that domestication of chili peppers had occurred long before these sites were occupied and that cultivation was routine. Where domestication of the five species of *Capsicum* occurred is currently speculative; based on modern distribution and genetic analysis, *C. annuum* is thought to have been domesticated in Mexico or northern Central America, *C. frutescens* in the Caribbean, *C. chinense* in Amazonia, *C. baccatum* in Bolivia, and *C. pubescens* in the southern Andes. *C. baccatum* and *C. pubescens* are taxonomically distinct, but the other three are members of a species complex and perhaps not really "wild" species at all.

Humans have, in a very short time, radically altered both the characteristics and distributions of the organisms we value. New data types like the starch microfossils discovered by Perry *et al.* have enormous potential to help investigate the trajectories for domestication, cultivation, and trade in a wide variety of crops whose histories have remained difficult to unravel due to their lack of preservation or their tropical origins. Data like these will also be useful beyond the study of a few crop plants. They have the potential to help in efforts to understand the links between human transport and invasive species, thus contributing to the challenge of biodiversity conservation.

References

1. L. Perry *et al.*, *Science* **315**, 986 (2007).
2. G. Barboza, L. de B. Bianchetti, *Syst. Bot.* **30**, 863 (2005).
3. J. J. Tewksbury *et al.*, *J. Chem. Ecol.* **32**, 547 (2006).
4. B. Pickersgill *et al.*, in *The Biology and Taxonomy of the Solanaceae*, J. G. Hawkes, R. N. Lester, A. D. Skelding, Eds. (Academic Press, London, 1979), pp. 679–700.
5. A. M. De, *Capsicum* (Taylor & Francis, London, 2003).
6. D. E. Symon, L. Haegi, in *Solanaceae III*, J. G Hawkes, R. N. Lester, M. Nee, N. Estrada R., Eds. (Royal Botanic Gardens, Kew, Richmond, Surrey, UK, 1991), pp. 197–210.
7. Millennium Ecosystem Assessment, *Ecosystems and Human Well-Being: Biodiversity Synthesis* (World Resources Institute, Washington, DC, 2005); see www.maweb.org/documents/document.354.aspx.pdf.
8. S. Knapp, *J. Exper. Bot.* **53**, 2001 (2002).

10.1126/science.1138308

NEUROSCIENCE

Where Am I?

Studies in rats reveal that the key to interpreting spatial information—where we are compared to where we've already been—may lie in the hippocampus.

André A. Fenton

The Greek philosopher Heraclitus famously observed, "You can never step into the same river; for new waters are always flowing on to you." How do we recognize a place as the same, even when it is different? How do brains routinely activate the same representations in response to somewhat different experiences? When is experience the same but different, and when is it just plain different?

Neuroscientists are getting closer to obtaining answers by recording the activity of neurons in the rat hippocampus that signal the animal's location. One of these "place cells" (*1*) only discharges rapidly when the animal is in a specific part of the environment corresponding to the cell's "firing field." The collective discharging of place cells allows us to predict the rat's location (*2*) by, in a sense, reading its mind. Knowing a rat's location from the activity of its neurons is astonishing given that rats, like people, have no specific spatial sense organs analogous to, for example, the visual or auditory systems. Somehow spatial knowledge is assembled by the brain. On page 961 of this issue, Leutgeb *et al.* (*3*) provide the latest insight into how spatial information is computed and transformed into spatial awareness, or knowledge, through distinct networks of neurons in the hippocampus.

Leutgeb *et al.* recorded hippocampal activity while rats foraged in seven boxes that systematically varied in shape between a circle and a square. Similar "morph boxes" were previously used by others to record from CA1 (*4*), the information output region of the hippocampus. The earlier study found that a rat forms distinct neural "representations" (patterns of activated place cells) when occupying either a circular or square box. Neither the fields of place cells nor their firing (activity) rates are related—that is, there is global remapping of neuronal activity in CA1 when a rat moves between the two different box shape environments. Moreover, only the circle or the square neural representation is activated for all the morph box shapes; boxes that are more circle-like activate the circle representation in the hippocampus, whereas square-like boxes activate the square representation. The activation state changes coherently across CA1 cells. These findings suggested that the CA1 region lumps spatial information into categories (in this case, circle or square categories). Thus, a rat perceives itself to be in either a circular or square box and the appropriate spatial memory gets activated by mechanisms with attractor network properties. The collective activity in a neural network defines its state. An equilibrium state, called an attractor, is akin to a memory (*5*). Attractor network responses to input are analogous to a ball on a bumpy surface. The network and the ball quickly settle into a nearby attractor until the inputs change enough to switch attractors.

In 2005, Leutgeb and colleagues (*6*) had done essentially the same experiment with morph boxes, but also recorded from CA3, the hippocampal region projecting to CA1. For unknown reasons, they got a somewhat different result from the earlier study. Global remapping occurred at a particular stage in the morph box sequence for only a subset of cells ("lumpers") in both hippocampal regions. Other neuronal subsets, so-called "splitters," changed by rate remapping—systematically increasing or decreasing discharge rates across the morph sequence while maintaining firing field locations (*6*, *7*). The result sug-

---

The author is in the Department of Physiology and Pharmacology, Robert F. Furchgott Center for Neural and Behavioral Science, State University of New York Downstate Medical Center, Brooklyn, NY 11203, USA. E-mail: afenton@downstate.edu