ature changes with 20th century observations, Esper et al. scale their series by matching the magnitude of its multidecadal trends to those in Northern Hemisphere mean (land and marine) annual temperatures from 1900 to 1977. After smoothing to remove year-to-year fluctuations, the records can be matched closely with either the annual or summer mean temperatures, because their trends over this period are very similar.

For the early 17th century, annual temperature estimates from Esper et al. differ by about 0.7°C from those of Mann et al. [see figure 3 of (1)]. However, when we re- gressed the record of Esper et al. against nonsmoothed data (see the figure), this difference was reduced to about 0.4°C. Recal-ibrating both curves against year-by-year warm season temperatures (10) reduces this difference further to about 0.35°C.

The results of calibrating any proxy data depend on whether raw or smoothed records are used and on the chosen seasonal temperature predictand. Reconstructions of annual temperature records with predictors that are strongly influenced by summer conditions, assume stationary relationships between proxy and summer climate and be-

tween annual and summer climates (and hence between summer and winter). The relationship was stationary over the Esper et al. calibration period, but over other periods it may vary: summer warming of extra- tropical land has progressed at a slower rate than winter warming in the Northern Hemi- sphere (by about 0.6°C since 1860, see dotted line in the figure) and this is predicted, on the basis of climate model experiments, to continue over the next century at least.

Whatever the true degree of cold in the 17th century, a surprising aspect of the results of Esper et al. is the indication of equally cold conditions throughout the 12th, 13th, and 14th centuries, where their reconstructed temperatures are consistently well below those indicated by all other records. On the evidence of this new series, the last millennia was much cooler than previously inter- preted. The warming of the 20th century is seen more clearly as a continuation of a trend that began at the start of the 19th cen- tury, not the early 20th, and an early period of warmth in the late 10th and early 11th centuries is more pronounced than in previ- ous large-scale reconstructions. This warmth also peaks slightly earlier than could be cap-
tured in the shorter Mann et al. record and is warmer than in any previous reconstruction.

Even accepting the knotty issue of re- construction uncertainty, the curve of Es- per et al. provides evidence for greater cli- mate swings in the last 1000 years than has yet been generally accepted. We need more independent reconstructions like this, based on improved proxy records, and we need to know why it was once so warm and then so cool, before we can say whether 21st-century warming is likely to be nearer to the top or the bottom of the latest IPCC range of 1.4° to 5.8°C (2).

References and Notes
10. K. Briffa, T. Osborn, data not shown.
11. T. O. was supported by the UK Met Office (PB/35359).

PERSPECTIVES: SIGNAL TRANSDUCTION

Hot and Cold TRP Ion Channels

David E. Clapham

Sipping a cold mint julep on a hot summer’s day evokes several different pleasant sensations in the nervous system. Recent papers from McKemy et al. (1) and Peier et al. (2) lift some of the mystery surrounding these sensations. These two groups identify an ion channel that is opened (gated) by both cold temperature and menthol, a cooling agent from the mint plant. This ion channel belongs to the transient receptor potential (TRP) superfamily first identified in the photoreceptor cells of the fly. The new channel opens in response to mildly cold temperatures (15°C to 25°C), admitting Na+ and Ca2+ ions into sensory neurons, which then become depolarized. The sensory neurons that express the new channel are in the mouth, projecting to dorsal root ganglia of mice, and variously called TRPM8, a related channel TRPV1 [VR1 (3)], and a related channel TRPV2 [VR1L (4)], which responds to burning heat (>52°C) (5). On the basis of published data, and their own experiments on trigeminal ganglia, they hypothesized that an unidentified protein sensed both cold and menthol. Expression cloning has been the key to identifying receptors that mediate other senses such as smell and taste. Although laborious, the method is robust in that it correctly identifies the protein per-

The two papers take very different routes to arrive at the same conclusion. McKemy and colleagues have previously identified and extensively characterized the “hot” pepper (capsaicin)/heat (>43°C) sensor, called TRPV1 [VR1 (3)], and a related channel TRPV2 [VR1L (4)], which responds to burning heat (>52°C) (5). On the basis of published data, and their own experiments on trigeminal ganglia, they hypothesized that an unidentified protein sensed both cold and menthol. Expression cloning has been the key to identifying receptors that mediate other senses such as smell and taste. Although laborious, the method is robust in that it correctly identifies the protein per-

forming a known function. Using this method, McKemy et al. discovered that a protein previously identified in prostate cancer cells—and variously called TRPM8, CMR1 (for cold and menthol receptor 1) or Trp-p8 (6)—was also present in dorsal root ganglia and trigeminal ganglia of mice, and responded to both cold and menthol.

Realizing that a cold sensor exists in dorsal root ganglia, Peier et al. identified a known gene with domains that have homology to the fourth and sixth transmembrane do-
mains of the hot pepper/heat receptor TRPV1. These transmembrane domains were closely associated with gating the channel. Using reverse transcriptase-polymerase chain reaction, they identified the TRPM8 channel in dorsal root ganglia and showed that it was ac-
vatated by cooling in the 15°C to 22°C tempera-
ture range, and by menthol. Both studies showed that menthol slightly raises the tempera-
ture threshold for TRPM8 activation. McKemy et al. also extensively characterized the pharmacological response of trigeminal sensory neurons to menthol and its more po-
tative relative icilin.

The mammalian TRP channel family is defined primarily by structural homology within the transmembrane-spanning domains, but overall sequence identities between mem-
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Of Predators, Prey, and Power Laws

Pablo A. Marquet

Power laws, in which one quantity can be expressed as some power of another, are ubiquitous in physical and social systems. They have been used to describe phenomena as diverse as the frequency of earthquakes of different magnitudes (the Gutenberg-Richter law), the distribution of income among individuals (Pareto’s law), and the rank-frequency distribution of city sizes, or words in natural languages (Zipf’s law) (1, 2). Power laws in the form of scaling or allometric relations are used by biologists to express how physiological, ecological, and life-history attributes relate to body size ($W$) raised to a power, usually a multiple of 1/4 (3). Among the vast number of biological power laws, those related to energy acquisition, transformation, and delivery are of fundamental importance, because energy sustains life. Thanks to the work of Max Kleiber in the 1930s, we know that the amount of energy organisms need to extract from their environments to sustain themselves, metabolism ($M$), scales with body mass according to $M \propto W^{3/4}$ (Kleiber’s law) (4). This simple power law represents a fundamental first principle whose consequences for the structure and operation of ecological systems we are just beginning to appreciate. On page 2273 of this issue, Carbone and Gittleman (5) demonstrate that the interaction between metabolic requirements and locally available energy can account for the observed power law relation between carnivore population density and body size. Their approach illustrates the importance of incorporating local ecological information if we are to understand large-scale patterns in biodiversity.

It follows from Kleiber’s law that a lim-

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