vents, which would have been of great selective advantage. Once capable of infrared phototaxis, they were pre-adapted for photosynthesis, and bacteria that accidentally drifted up into the photic zone could then exploit sunlight.

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Single odorant molecules?

SIR — Can vertebrate olfactory receptor cells detect single odorant molecules? Menini *et al.*[1] suggest that under some circumstances this may be so. But we do not think that their paper demonstrates this conclusion.

If, as Menini *et al.* appear to imply, the smallest isolated current bumps in their Fig. 1*b* (0.5 μM cineole trace) were evoked by single molecules, then doubling the odorant concentration should have doubled the number of these events. However, looking at the response evoked by 1 μM cineole, it is clear that the number of events was much more than doubled. This discrepancy cannot be explained by nonlinear summation as Menini *et al.* suggested, because nearly all simultaneous events would have occurred in different cilia, and therefore would have summed linearly, given the low rate of 'quantal-like' events in the 0.5 μM trace ($<1\ s^{-1}$).

A second problem with interpreting the current bumps as single-molecule responses is the extraordinarily high odorant concentration required to evoke "on average very few" such events. During each of the 0.5-s, 10-μM cineole stimuli in Fig. 3 of ref. 1, at least 10^8 odorant molecules had access to the cilia by diffusion (calculated by approximating each cilium by a highly elongated ellipsoid of revolution[2], and assuming a diffusion coefficient of $5 \times 10^{-6}\ cm^2\ s^{-1}$ and 10 cilia, each 30 μm long). Yet, according to the interpretation of Menini *et al.*, these stimuli evoked "on average very few" events (two events based on the frequency of "failures"[3]). Thus, interpreting the current bumps as single-molecular responses implies a remarkably low probability of odorant–receptor interaction, contradicting evidence that a single molecule is sufficient to activate transduction[4].

Finally, the conclusion of Menini *et al.* depends on the assumption that the current bumps result from quantal activation of transduction, not other sources of noise in the transduction mechanism. We have reported similar current fluctuations in rat olfactory receptor cells, but showed that they reflect noise intrinsic to the transduction mechanism, probably caused by spontaneous fluctuations in the basal cyclic AMP concentration[5,6]. One might assume that intrinsic transduction noise cannot contribute to the measurements of Menini *et al.* because the baseline current exhibits little noise in the absence of odorants. However, this is not true, because the threshold for current generation by cAMP will attenuate basal transduction noise[7]. This threshold can also explain the discrete (quantal-like) appearance of the smallest odorant responses, because fluctuations in cAMP concentration that only rarely exceed the threshold will generate discrete quantal-like current bumps. Such a threshold effect could very well explain the quantal-like appearance of the odorant responses in ref. 1, because the transduction current exhibits roughly a fourth-power dependence on odorant concentration[8], presumably due to the nonlinearity of current generation[7]. This nonlinearity also undermines their estimating quantal-event amplitude from the histogram in Fig. 3 of ref. 1, because this type of analysis assumes a linear relationship between current and the number of quantal events[9].

In summary, we believe that the quantal-like current bumps reported in ref. 1 are explained more readily by intrinsic transduction noise than by quantal activation of transduction. In our view, a convincing demonstration of quantal responses must satisfy the same criteria as those that established quantal detection in photoreceptors: linear summation of independent events; Poisson variation in response amplitudes; and agreement between the stimulus magnitude and the number of quantal events[3]. Future studies should also consider the effects of nonlinear current generation and intrinsic transduction noise.

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Eemian climate and pollen

SIR — Field *et al.*[1] have presented quantitative palaeoenvironmental reconstructions for the last interglacial period (the Eemian) in western Europe based on pollen data from two sites (Bispingen in northwestern Germany and Grande Pile in eastern France). In their reconstructions the authors use climate response surfaces and measure the degree of analogy between fossil and modern pollen spectra in order to arrive at their nearest modern analogues. Climate reconstructions were attempted so as to check the pollen evidence for possible Eemian climate oscillations similar to those reported from the GRIP ice core[2].

The palaeoclimate reconstruction for Bispingen, situated in the German lowlands 50 km south of Hamburg, gave a surprising result. Whereas Eemian summer temperatures were similar to those of the present warm period, winter temperatures during the latter half of the Eemian were very low, with mean temperature of the coldest month (MTCO) averaging −10 °C. This corresponds to present-day temperatures in northern Belarus. During this long period of cold winters there was even an interval with extreme conditions where MTCO decreased to −20 °C, corresponding to the present climate in central Siberia and to supposed temperatures in western Europe during pleniglacial conditions. Present-day MTCO for the Bispingen locality is −0.3 °C.

This palaeoclimate reconstruction is very unlikely in the light of uncontested evidence indicating that during this period of supposed severe winters in the lowlands of western Europe, the North Atlantic Ocean and the Norwegian Sea were open waters at least as warm as those of today[3]. The reconstruction is directly contradicted by the occurrence of pollen of the indicator plants ivy (*Hedera helix*) and holly (*Ilex aquifolium*), which require MTCO well above −5 °C (ref. 4), both in the original Bispingen pollen diagram[5] and in a large number of Eemian pollen diagrams from nearby localities in the lowlands of northwestern Europe[6].

The discrepancies may be related to difficulties inherent in the technique used for palaeoclimate reconstruction. One main difficulty is to find modern analogues for fossil pollen assemblages. In many cases strict parallels do not exist. In the reconstruction of the Eemian climate in western Europe, this problem is especially acute because one of today's dominant tree species, beech (*Fagus sylvatica*), was not present in the area in previous interglacials. The reason for this absence is not fully known, but does not seem to be climatic[7]. Beech was also absent from