effects will continue to increase at the same rate for subsequent global increases in temperature such as that expected due to increases in 'greenhouse' gases.

Second, as Ramanathan and Collins imply, their mechanism does not provide an absolute limit for climatic warming. For example, increases in solar constant or CO_2 would increase their apparent upper limit to sea surface temperatures. More important, in simulations of global warming due to increases in atmospheric CO_2, moist static energy increases through the depth of the tropical troposphere (see refs 3,4) raising the apparent threshold for deep convection and so also the maximum for sea surface temperature. This, combined with the supposition that the approach of Ramanathan and Collins may exaggerate the rate of increase of radiative effects with global temperature because it includes a contribution from local dynamics, suggests that although increases in cirrus cloud may produce a negative feedback with increases in tropical sea surface temperature, it is not as strong as Ramanathan and Collins imply.

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Zinc and GABA in developing brain

SIR — In the adult hippocampus, GABA, acting on GABA-A receptors, provides most of the inhibitory drive; a selective block of GABA-A receptors causes seizures. In contrast, during the first week of postnatal life, GABA-A receptors provide most of the excitatory drive, and GABA-A blockers induce an electrical silence[1]. One of the striking correlates of these changes is the presence in hippocampal neurons, during the first week of postnatal life, of synchronized network-driven GABA-A mediated giant depolarizing potentials (GDP) which we believe[1] are generated by recurrent and feed-forward excitation of pyramidal cells and interneurons by GABA. Xie and Smart[2] suggest that GDP may be generated by endogenous zinc which, by means of a block of GABA-A receptors, increases GABA release. Although attractive, this hypothesis cannot easily be reconciled with the following observations.

Zinc has several complex effects on receptor-gated and voltage-dependent channels which could mediate its effects on GDP. It blocks the A current[3] and reduces the calcium-dependent potassium current as well as the slowly inactivating voltage-dependent calcium current[4]. It increases transmitter release in the neuromuscular function, an effect probably mediated by a rise in intracellular calcium[5], and increases AMPA-mediated currents[6]. Furthermore, in adult hippocampal slices, GABA-B receptor antagonists do not generate GDPs; a depolarizing GABA-mediated synaptic current can be generated by 4-AP which blocks the voltage dependent potassium A and D currents[7].

The zinc-enriched mossy fibre terminals constitute the only possible source for the high concentrations of zinc required to generate GDPs (200–300 μM). The mossy fibres, however, had a delayed development: by day 10 of postnatal life mossy fibres are developed and there are no GDPs, whereas at day 1 GDPs are present and there are essentially no mossy fibre terminals.

The parallelism suggested by Xie and Smart between the effects of zinc in rat neonatal slices and the fifth-day fits in newborn animals is hazardous because of the considerable differences in maturation stages between the two species (the first seven days of life in the rat correspond to the fetal period in man).

Xie and Smart suggest that the functional significance of GDPs may be a rudimentary form of dendritic inhibition. We prefer the hypothesis that GDPs and the depolarizing effects of GABA provide an excitatory tone to developing hippocampal neurons, reflecting a possible trophic role of GABA in growth and differentiation. There are several lines of evidence to support this suggestion: first, in neonatal neurons activation of GABA-A receptors induces a large increase in intracellular calcium; and second, block of GABA-A receptors by bicuculline retards hippocampal cell growth and neurite formation in culture[8].

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Firefly synchrony

SIR — Ian Stewart in News and Views[1] claims that Mirollo and Strogatz[2] have developed a theory that can explain the synchronization of huge congregations of South East Asian fireflies (*Pteroptyx malaccae*) as well as hippocampal neurons, menstrual cycles and the insulin-secreting cells of the pancreas. Although Mirollo and Strogatz do prove that synchronization of oscillators occurs, their results apply to a special class of models in specific geometries, namely 'all to all' coupled-phase advance oscillators. They point out in their paper that the model is inappropriate for *P. malaccae* and would better suit the responses of the non-congregating North American species *Photinus pyralis*.

Mirollo and Strogatz suggest than an oscillator will *advance* its phase instantaneously to a pulsatile stimulus. This immediately implies that such an oscillator cannot be entrained to lower-frequency periodic stimuli. *P. malaccae* is able to entrain to periodic light pulses above and below its intrinsic frequency[3] and, once it is entrained, the phase lag is almost zero: The animals actually alter their intrinsic frequency to match that of the stimulus and, once the stimulus is removed, slowly return to their original frequency. The entrainment requires many cycles of the stimulus which is not so for the pulsatile phase-advance synchrony reported in ref. 2.

The geometry of connections in ref. 2 is also somewhat unrealistic since it assumes that all oscillators are connected to all others. In congregating groups of fireflies the insects tend to space themselves out so that they are no closer than about a third of a metre apart. They will ignore the flashes of any animal that is farther than about a metre[4]. Thus any given insect sees about 100 others. In a tree with thousands of animals, the coupling is far from 'all to all'.

The real question of interest is how the animals modify their intrinsic frequencies in such a way as to achieve almost perfect synchrony. Mirollo and Strogatz make a valuable contribution in analysing collections of pulse-coupled oscillators, but Stewart's claim that "all these systems attain synchrony by the same mathematical mechanism" ignores a large body of facts about these diverse and fascinating biological phenomena.

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