into longitudinal photons every second will be $(c/L)(\lambda/\lambda_c^2) = 1/\tau$. Also $1/L \simeq n\sigma$, where n is the density of scatterers and σ the scattering cross section. We are concerned with the photons of the fireball moving through hydrogen, and can assume σ to be the cross section for Rayleigh scattering: $\sigma \simeq a^2\lambda_b^4/\lambda^4$, where a is the classical electron radius and λ_b is the wavelength corresponding to the binding energy for hydrogen, about 10^{-5} cm. Both λ and n will change because of the expansion of the Universe: $\lambda = S\lambda_0$ and $n = n_0/S^3$, where λ_0 and n_0 are the quantities at epoch t_0 and S is the cosmological scale factor, chosen so that $S_0 = 1$. That gives:

$$\tau \simeq S^5\lambda_0^2\lambda_c^2/cn_0a^2\lambda_b^4$$

The factor τ depends strongly on S, which is now of the order of 1,000 if the initial epoch is that of the decoupling of the fireball radiation and matter; it is smallest when $S = 1$, $n_0 \simeq 10^4$ atom cm^{-3} and $\lambda_0 \simeq 10^{-4}$ cm. If $m = 10^{-52}$ g (ref. 4) then $\tau \simeq 10^{44}$ yr. Thus, the fraction of longitudinal photons in the field after even many times 10^{10} yr is negligible. Even though long times are available, the free paths of photons are too long for sufficient scattering events to occur.

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Do epicentres migrate on the San Andreas Fault?

WOOD AND ALLEN[1] have suggested that seismicity on a portion of the San Andreas Fault can be used in support of a model of recurring migration of epicentres. They considered 27 earthquakes of magnitude, $M \geq 5$ within 30 km of the fault between 35.5°N and 38.5°N which occurred between 1930 and 1972. Five parallel line segments are drawn through the time-latitude plot of 27 points; the common slope of the lines is presumed to give the velocity of migration of earthquakes. Several of these events correlate with one another; any line in the neighbourhood of events that are close together in latitude and time will provide a satisfactory fit. Obvious clustered events are the quadruplet (1,2,3,4) and the pairs (15,16; 5,6; 19,20; and 25,26) (Table 1 of Wood and Allen). Probably, other correlated events could be found were a different model used. Further, event 13 seems not to have been used in the fit.

Thus, there are 19 or fewer independent events in the data set. If a model is used in which the slopes of the line segments are fixed, then there are 19 or fewer degrees of freedom in the data, which are used to fit the intercepts of the segments.

The number of degrees of freedom in the model used by Wood and Allen may be about 15 in addition to the common slope: that is, the intercepts and end points of each of the five lines. The number of degrees of freedom in the end points is a function of the length of the segments and is difficult to evaluate. Thus, the number of degrees of freedom in the model is roughly equal to the number of degrees of freedom in the data, and we conclude that there are inadequate data to support the parametric complexity of the migration model. We believe that the apparent migration of epicentres along part of the San Andreas Fault is an artefact of Wood and Allen's model.

Wood and Allen forecast an earthquake with $M \geq 5$ in a restricted time–space interval along the San Andreas Fault. Though the complexity of the model makes it easy to give qualitative predictions, quantitative predictions in terms of probabilities remain difficult. Wood and Allen have avoided the question of estimating the risk that is: the probable number of shocks that will occur in the time–space region identified as dangerous. We can calculate the risk on the basis of a simpler model involving a considerably smaller number of degrees of freedom. Suppose that earthquakes are Poissonian between 36.75° and 37.05°N. Seven earthquakes are then found in the 25 yr × 33 km time–space region; the area identified as dangerous by Wood and Allen is about 6 yr × 17 km. Thus, 0.86 ± 0.31 shocks can be expected in the defined time–space interval. Dropping the constraint that the earthquake catalogue has a space–time envelope, and assuming instead that shocks occurred randomly between 1930 and 1972, then 0.50 ± 0.19 shocks with magnitudes of more than five will occur in the smaller time–space interval.

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Competition and species abundance

HEBERT *et al.*[1] used samples of the aerial population of Macrolepidoptera, collected at light in Ontario, Canada, to advance an argument in competitive population dynamics. Although not entirely explicit, it seems to run as follows. Given the "generally conceded" initial premise that interspecific competition is greatest between closely related sympatric species, the hypothesis that species abundance is controlled by level of competition can be tested by the relationship between mean species' population density and their taxonomic distance. In other words, in a sample from a multispecies population, the mean number of individuals per species in each family (N_s) is expected to be negatively correlated with the number of species in that family (S_f); making the provisional assumption that the relationship is causal.

The general conclusion reached by Hebert *et al.*[1] from their evidence of an inverse relation between family size and the abundance of species, was as expected; "family differences . . . are due to competitive interactions." The experiment raises questions at all levels, technical, analytical, interpretative and logical and, because the issue is a central one, we will take these up in more detail elsewhere. Our present purpose is to show that results like these are not invariably obtained from samples of this kind and, therefore, the conclusion as stated is not general.

The data in Table 1 are sums of seven replicate samples, each one a single year's accumulation of nightly subsamples of Macrolepidoptera collected at light, from Malham in northern England[2] and Bangor in North Wales, as part of the Rothamsted Insect Survey[3] during 1966–72. These sites were selected from a much larger series because, in these particular instances, the relation between N_s and S_f is diametrically opposed to that given by Hebert *et al.*; the correlation is positive, not negative.

The use of selective samples to investi-

Table 1 Species abundance and mean no. of individuals per species in each family at two selected sites in Britain

	Malham		Bangor	
	S_f	N_s	S_f	N_s
Noctuidae	86	69.03	79	10.00
Geometridae	75	90.51	103	27.15
Arctiidae	5	4.60	6	4.00
Notodontidae	4	9.75	2	3.50
Sphingidae	1	6.00	2	1.50
Other families*	1.6	16.63	2	2.33

* Five at Malham and six at Bangor.