Table 1. Cation Exchange Capacity Values for Armadale B_h Soil and Organic Matter

Material	M.equiv./100 g soil	% Cation exchange capacity
'Difference' method		
Untreated soil	18·7	100·0
Soil after destruction of organic matter (= inorganic portion)	5·7	30·5
Due to organic matter	13·0	69·5
Organic matter extracted and purified		
Inorganic portion	5·7	8·1
Extracted and purified organic matter (humic + fulvic acids)	65·0	91·9
	70·7	100·0

cannot be made by the 'difference' method. Because in most predominantly inorganic soils only 20–30 per cent of the organic matter can be extracted, meaningful estimates of the organic exchange capacity can be made only in those soils in which either the bulk of the organic matter can be extracted, such as podzol B_h horizons, or in organic soils where most of the inorganic constituents can be extracted from the organic matter. (2) The results in Table 1 suggest that in the case of soils containing appreciable amounts of organic matter two types of cation exchange capacities should be considered: (*a*) 'measured' cation exchange capacity as determined by exchange with NH_4^+ or any other ion one might choose to use; (*b*) 'potential' cation exchange capacity, that is, 'measured' cation exchange capacity plus cation exchange capacity due to blocked organic exchange sites which are inaccessible to or do not react with exchange ions. These blocked sites can be unlocked and measured by methods such as have been used in this investigation. Thus, the 'potential' cation exchange capacity of soils might be several times greater than the 'measured' one. From the foregoing a practical application is suggested: if organic exchange sites presently blocked by inert iron and aluminium compounds could be filled with ions more beneficial to plant nutrition, soil productivity might be increased.

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MISCELLANY

Probability of Life

Prof. H. F. Blum has given reasons for believing that the probability of the development of life up to the present human cultural level on our planet is unlikely to exceed 10^{-18} (ref. 1). His arguments may well be valid if they are supposed to apply to our specific civilization with its Ford cars and hybrid maize and antifluoridation societies. There is, however, a simple fallacy involved when Prof. Blum suggests that this minute figure should "give our imagination pause in peopling the universe with living things, particularly with 'intelligent' life approaching closely the characteristics of men".

The probability of any set of bridge hands being dealt twice running to the same four people from well-shuffled packs is in the region of 10^{-31}. There is no comparable improbability that the second deal will yield something usable for the purpose of playing bridge.

Since the beginning of life on this planet, Prof. Blum suggests that not less than 10^9 successful mutations have gone to the making of the present million or so living species.

Hence he deduces that the probability of biological evolution having reached its present state is of the order of 10^{-9}. Even if we grant this numerical deduction for the present particular set of species—though for this 10^{-9} seems incredibly large—it neglects the fact that if any one of the successful mutations had not occurred, some other mutation would have been successful. Without going into any numerical detail at all, it is surely clear that, once a mutatable life has started, the probability that some assortment of living species should exist at any future time is not 10^{-9} but unity (assuming that no catastrophe great enough to sterilize the entire planet occurs). Following Prof. Blum in treating man as a special case, there seems no reason for thinking that the rest of the present living species are unexpectedly complex in number or variety; that they are more than a very ordinary bridge hand.

The development of a human level of intelligence might be considered seriously as a highly improbable event, but such palaeontological evidence as we have does not support such a consideration. Creatures in widely separated groups, and even in different phyla, have shown a continuous increase in brain size with time, so that though specific mutations may have been improbable, the kind of mutation leading to this was not. Even at the immediately pre-human level there seem to have been at least three evolutionary lines which learnt the use of tools.

Finally, Prof. Blum multiplies his improbability by a further factor of 10^{-6} to represent the improbability of the 'cultural mutations' leading to our present state. Again, if he is considering the probability that the world should have the particular pattern of nations and cultures that it has, his factor of 10^{-6} is probably far too large, but surely some kind of advanced culture had a probability approaching unity once the use of tools by creatures of human intelligence was established some tens of thousands of years ago.

A different path for some of the most vital 'cultural mutations' might have changed the rate of development —in either direction—as well as the final form, in quite major ways, but the ultimate development of a highly complex civilization was surely inevitable.

We do not yet know enough to be at all confident of the probability that life should arise in the first place in suitable conditions—Prof. Blum sets this as 10^{-3}—but once this is done, though there may well be 10^{18} or more major routes by which it can develop to organized intelligence, the chance of one of these routes being eventually found is surely very large indeed.

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Dr. Fremlin's analogy to probabilities of bridge hands seems far from applicable to evolutionary processes of the kind considered in my article. Before dealing a bridge hand the pack is thoroughly shuffled to avoid retention of patterns of arrangement of the cards. In evolution each step is predicated on an existing pattern which has been formulated in the course of previous evolutionary steps, the pattern being copied (by one means or another) and so retained between steps. Thus, the probability of a given step is to be reckoned in terms of existing pattern, not in terms of a shuffled arrangement as for a bridge hand. The analogy to computer operation used in my article seems more suitable and leads to a very different point of view.

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