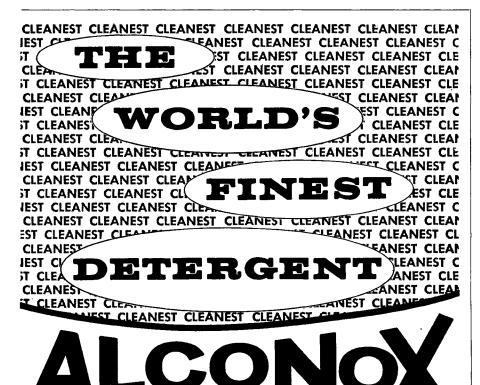information theory the following problem, which was examined by the mathematician Von Neumann. Suppose we wanted to build a machine capable of reaching into bins for all of its parts, and capable of assembling from these parts a second machine, just like itself. What is the minimum amount of structure or information which should be built into the first machine? The answer came out to be of the order of 1500 bits—1500 choices between alternatives which the machine should be able to decide. This answer is very suggestive, because 1500 bits happens to be also the order of magnitude of the amount of structure contained in the simplest large protein molecule which, immersed in a bath of nutrients, can induce the assembly of these nutrients into another large protein molecule like itself, and then separate itself from it. That is what the process called life consists of, and unless and until we discover a new process in which simpler molecules have semilife properties, the inquiry into the birth of life can be reduced to an inquiry into the possibility or probability of the spontaneous assembly of such a molecule, out of a bath of its essential constituents. And this is exactly where we run into an interesting difficulty.

SPONTANEOUS CREATION OF LIFE?

By making the most favorable assumptions as to the conditions in which this spontaneous creation of life could have occurred on this earth, we do not come anywhere near the spontaneous assembly of 1500 bits; we can account for perhaps one tenth that number. Do not shrug this off as being only one order of magnitude off. This involves a factor of 10 in the exponent, and there is a vast difference between the probability of 1 part in 2^{150} and 1 part in 2^{1500}. Then you might say: But it could have happened in many places in our universe, and if it had not happened here, we would not be here to talk about it.

Very well, multiply 2^{150} by the number of stars—that is, by the number of potential solar systems, in the universe—and you obtain 2^{220}, still short of the mark. And yet, life did begin, and looking back in time, we see two mysteries, or at least two highly unlikely events. The first, the creation of the universe, of space, of time, of matter. The second, the creation of life, from which we evolved as a matter of course almost, with such unlikely beings as physical chemists in our midst, producing in the laboratory improbable assemblages such as a liter of liquid helium, or saying such unlikely things as what I am now saying to equally unlikely assemblies of molecules as my listeners. We may even have some day an unlikely biochemist who will assemble, radical by radical, an unlikely large molecule which can reproduce itself. But this would not resolve the historical mystery of the creation of the first living molecule.