Abstract. A simple self-organizing model system of molecules is considered and it is demonstrated by a computer simulation, that a genetic code of 16 elements (aminoacids) can gradually be formed by such a system in the course of many generations. By a number of rare chance events, each suppressing other events of equal a priori probability, a single code results out of an immense number of possible codes of the same a priori probability. The result is discussed in relation to the uniqueness of the genetic code in living systems. The computer simulation emphasizes a particular step in a model pathway discussed elsewhere consisting of many assumed physicochemical steps leading to a genetic apparatus.

It is unclear how a genetic code could have been formed and it is not known why each species among the immense number of biological forms has the same code (Calvin 1969, Dose 1975). For approaching an answer it is of interest to study simple theoretical models. Using a simple self-organizing model system we demonstrate the gradual formation of a code of 16 elements (‘aminoacids’ 1 to 16) by a computer simulation. Each possibility of a code has the same probability to appear in the course of the computer simulation, but one code evolves. It depends on chance events which occur during the process.

The computer simulation is concerned with a particular step in a model pathway discussed in preceding papers (Kuhn 1972, 1976, 1977). This model pathway is obtained by starting with some reasonable initial situation, proceeding step by step, each time trying to trace a simple physico-chemical process. The basic question in modelling each step was: how do we avoid piling up replication errors, how do we find physico-chemical conditions by which assemblies of molecules develop to systems of increasing complexity?

The answer is seen in a specific environment structure being the driving force of the process. By this structure, which is periodic in time and many sited in space, evolution is initiated and driven towards a continuously increasing degree of complexity correlated with a continuous expansion of the populated area.

Important stages on that modelled pathway are the development of replicating strands, the development of assemblies of such strands obtained by aggregation, the development of aggregates which in addition have catalytic properties to produce a second class of macromolecules. These systems develop to assemblies in which this catalytic apparatus gets more and more complex and at this stage the situation emphasized in this paper is
reached. In a later stage another fundamental change in the organization structure is expected to occur and then the main organization structure of the genetic apparatus is achieved.

1. Basic model

In a theoretical model a simple situation is considered and the consequences are analysed. This method of modelling idealized processes in thought experiments has proved to be fruitful in physical chemistry and should be useful in the search for principal mechanisms in selforganization. The detailed picture that must be given for any model case to analyse its consequence should not be misinterpreted. A hypothetical model pathway of evolution must be an unbroken detailed chain. This chain should be considered as a strongly idealized possibility, focussing on main features of the process, and not as a detailed picture for an historic event.

The model that has been considered (Kuhn 1972, 1976, 1977) is based on the idea that short molecular strands obtained by condensation of monomers are stimulated to undergo multiplication and selection. The stimulus is a very special environmental structure, that is periodic in time, caused by the change between day and night, the tides or the seasons. Monomers attached to appropriate chains polymerize, thus forming complementary chains. By appropriate changes of environmental conditions (e.g. increase of temperature) the double strands fall apart. As soon as the original conditions are reached again, complementary chains are again synthesized. By such a distinct periodic environmental change these particular concerted reactions are stimulated again and again. Daughter strands may be slightly changed by inaccuracies in the polymerization at the matrices. Therefore, in the selection phases many different convoluted forms will be present. They will be different in their ability to protect themselves against decay. The fittest will be accumulated in the course of the process.

The spatial structure of the environment stimulates an evolution to higher and higher complexity. Some times a form may be obtained which is able to survive in a region where the present forms cannot survive. Such a form obtained by a fortuitous error in the synthesis of the complementary chain will usually have a slightly increased complexity: an additional qualification requires a more complex structure. By this effect of hiding more complex forms in less hospitable regions a continuous increase of complexity coupled with a continuous extension of the populated area is reached: the slightly more complex form always accumulates in a region where there is no competition with the other forms.

A prebiotic earth presents the stimuli of evolution in the suggested manner: a many-sided environmental structure changing periodically in time.

By such considerations the model system discussed below is obtained in many steps. Important stages on that model pathway are:

(1) the evolution of aggregates of replicating molecules. At this stage assemblies of molecules act as individuals, in the sense of being subject to multiplication, mutation and