Postscript to the afterword

John von Neumann's last unfinished work, „The Computer and the Brain" was published in Hungarian in 1964. Two years later, in 1966, a book was published in the USA in which the theoretical works on automata theory found in the estate of John von Neumann were collected. This revealed that his last work, The Computer and the Brain, was actually the last, unfinished work in a series of five. These are:

1. The general and logical theory of automata. Talk at the Hickson symposium in September 1948, which appeared in print in 1951.
2. Theory and organization of complicated automata. Five Lectures at the University of Illinois December, 1949. The manuscript was published only after the author's death (Theory of self-reproducing automata by John von Neumann. The manuscript was arranged for printing and supplemented by Arthur W. Burks. University of Illinois Press, 1966.)
3. Probabilistic logic and the synthesis of reliable organisms from unreliable components. Proceedings of lectures delivered at the California Institute of Technology, January 1952.("Automata studies, edited by C. E. Shannon and J. MacCarthy, Princeton University Press, 1956.)
4. Theory of automata: construction, reproduction, homogeneity. Neumann began work on the manuscript in the autumn of 1952 and worked on it for about a year. Published only after the author's death, in the above-quoted work by Burks.
5. The Computer and the Brain. The author started the book in 1955 and worked on it until his death.. The first edition was published in 1958.

The works published after the author's death make fascinating reading in their own right. Comparing the material of the five essays with each other, it is clear not only that Neumann's way of thinking and his individual style of work are clearly recognizable, but also that in the works mentioned problems that he had already discussed in 1949 at the Hickson symposium. These are briefly summarised as follows:

1. A systematic comparison of computers and the brain. This problem is elaborated in detail in his last paper and he concludes that "the brain is not using thelanguage of mathematics".

2. The role of complexity in the organisation of automata. This problem is discussed in the University of Illinois five lectures. The concept of complexity has a central role in the general theory of automata, as Neumann put it. Under a certain degree of complexity self-replication is impossible, similar to the release of atomic energy, which is impossible below critical mass.

3. Reliability and complexity. One of the important aspects of the complexity of a living organisms is that they are able to function in a very reliable way in a wide range of extreme environments, despite the fact that the structural elements themselves might be highly unreliable. This problem is addressed with full mathematical rigour in the lecture at the California Institute of Technology. With this work not only laid the foundations of the abstract automata theory, but this was the starting point for the reliability theory of technical equipment, and also a new branch of logic, the so-called threshold logic, which is characterised by the use of a neuron-like switching elements. Both fields have since developed libraries of literature.

4. Self-reproducing automata. The biggest problem connected with complexity is whether there is, and if so, what is the relationship between the complexity of an organism and its self-reproducing capacity. As mentioned above, this problem was already raised by the author in his lecture at the Hickson symposium, and gave a rigorous logical proof, that it is in principle possible to construct such automata, which can reproduce themselves and even evolve (in the sense of mutation).

The thought process of the proof, although relatively simple, does not fit into a short postscript. A "trick" is that the constructing automaton must contain a complete description of itself. Neumann obviously had in mind the genetic information, the structure of which was only discovered after Neumann's death. In his last work, published after his death, he explores this question in detail and gives a two-dimensional model of abstract 'cells' which, given sufficient complexity, is capable of reproducing itself.

It is a great loss to science that this problem has not been pursued because modern semiconductor technology is now capable of producing, in integrated circuits, structural elements whose dimensions are beginning to approach the cell size of a living organism. Once science has solved Neumann's problem, it could open up new horizons for mankind that today can only be found in science fiction novels.