

# MEASURES OF ORGANIZATION IN A MODEL OF CELLULAR SELF-REPRODUCTION BASED ON TURING MACHINES

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## 1. Introductory summary

The late John von Neumann first realized that self-reproduction, as observed in biological systems, was a legitimate problem of mathematics, specifically of automata and algorithm theory. He founded the study of self-reproduction in systems of "natural automata." This report deals with the self-organizing properties of a new type of cellular self-reproduction model. The action of enzymes is simulated by Turing machines acting as molecular automata or computers, with their highly standardized coding corresponding to genes of the cell. Computer experiments have been done to test the stability and logical homeostatic properties of a 36 gene cell model. It is shown that the system will continue to organize itself and reproduce in spite of a variety of environmental deficiencies and disturbances, and also to repair itself after certain kinds of injury. The most pertinent organizational criteria for the described model are amounts of "energy" and "time cycles" needed to reach maturity and reproduce. Comparisons are drawn between these organizational measures and thermodynamic informational parameters such as Gibbsean chemical potential and entropy. The total amount of genetic and cellular information can be quantified in the cell model and this helps clarify some confusing aspects of genetic information measures. The model is highly idealized. It bears somewhat the same relationship to real cells as computer circuits do to the brain, but shows that automata theory can be applied to molecular biology in a meaningful way.

## 2. A model of self-reproduction based on Turing machines

Previous reports [1], [2], [3] described a cell model in which the principal logical tool is a molecular automaton that acts upon substances encoded as strings of symbols. The cell consists of a group of such enzyme automata that

Supported by Grants GM 13605-01 and FR 00163 of the National Institutes of Health. Publication No. 98 of the Oregon Regional Primate Research Center.