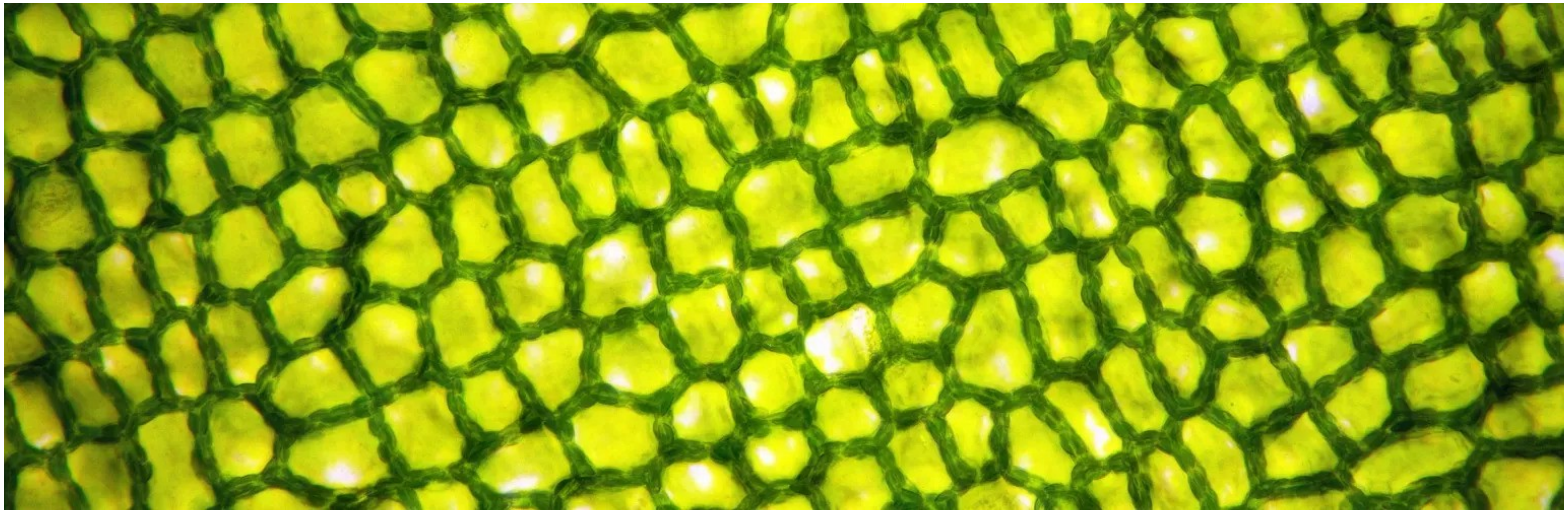
Sejtautomaták: Játékos modellektől a kvantumszámítógépekig

Pozsgay Balázs
MTA-ELTE ,,Lendület" Integrálható Kvantumdinamika Kutatócsoport
ELTE TTK, Elméleti Fizikai Tanszék

Az atomoktól a csillagokig,
2024. április 11.

Sejtautomata???

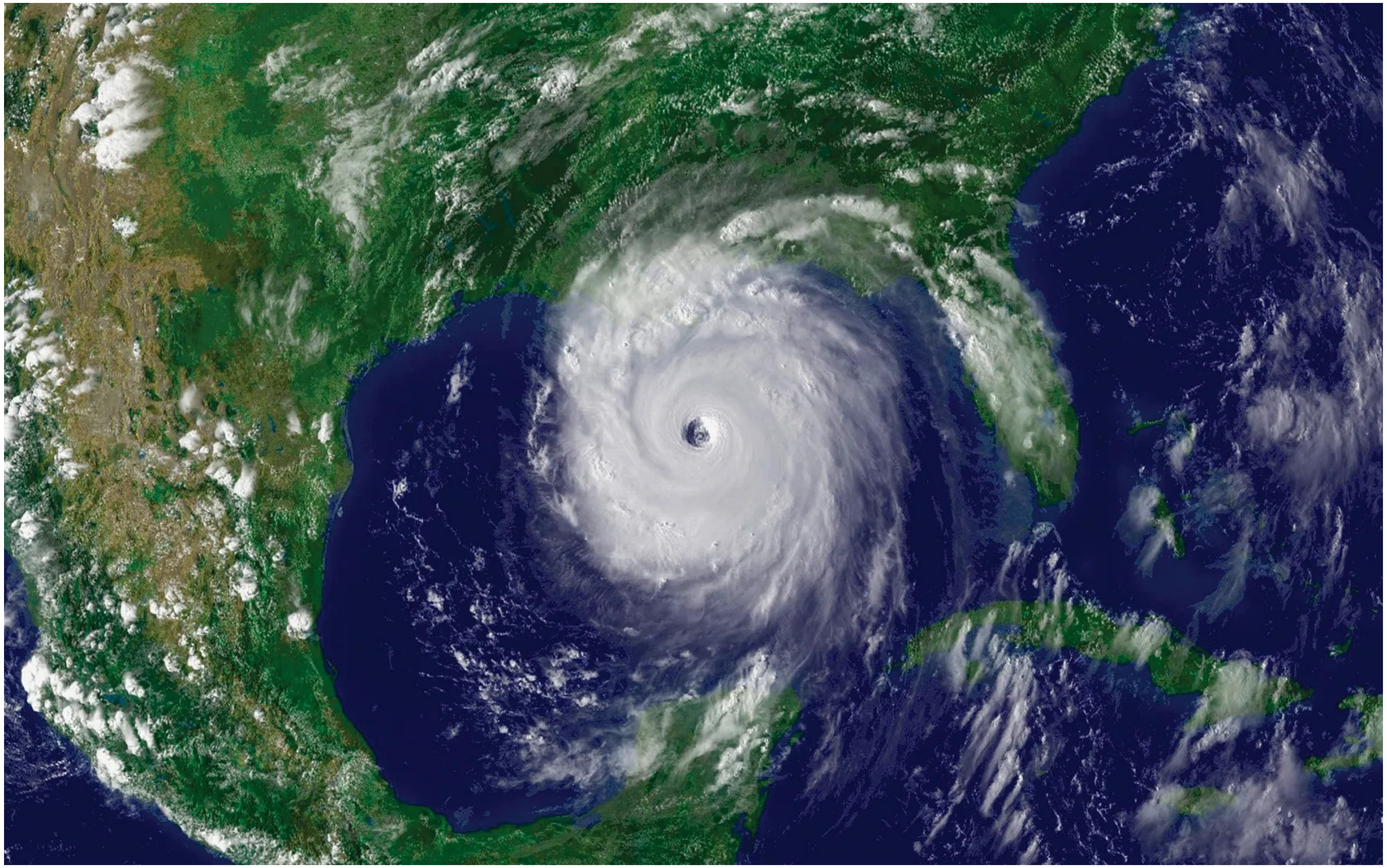


Tartalom:

- Motivációk, szabályok
- Egy dimenzió
- Két dimenzió
- Kvantumszámítógépek

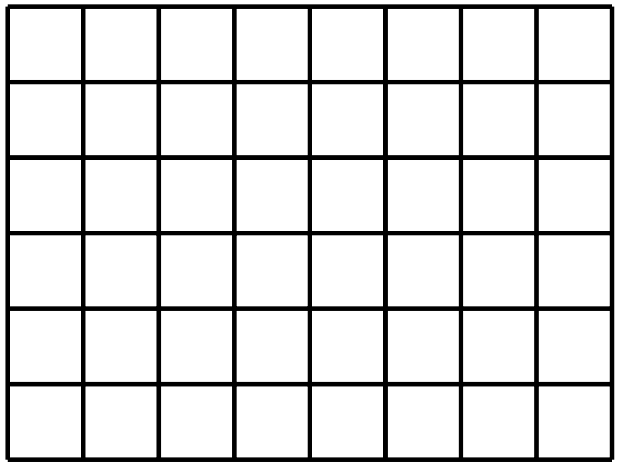
Bonyolult rendszerek a fizikában…

Időjárás

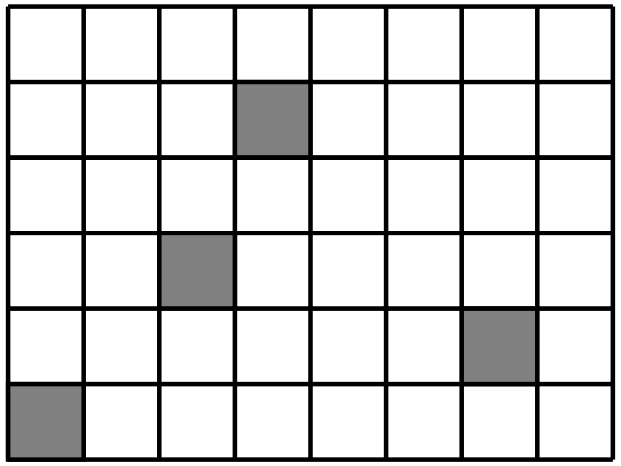


Sejtautomaták:

- Sejtek elrendezése



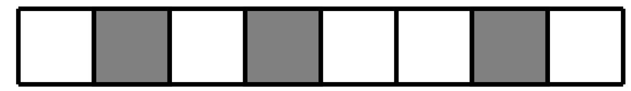
- Sejtek állapota



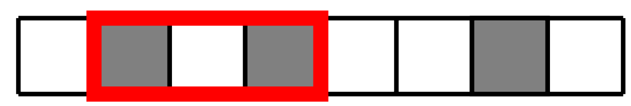
- Idő

- Időléptetési szabály

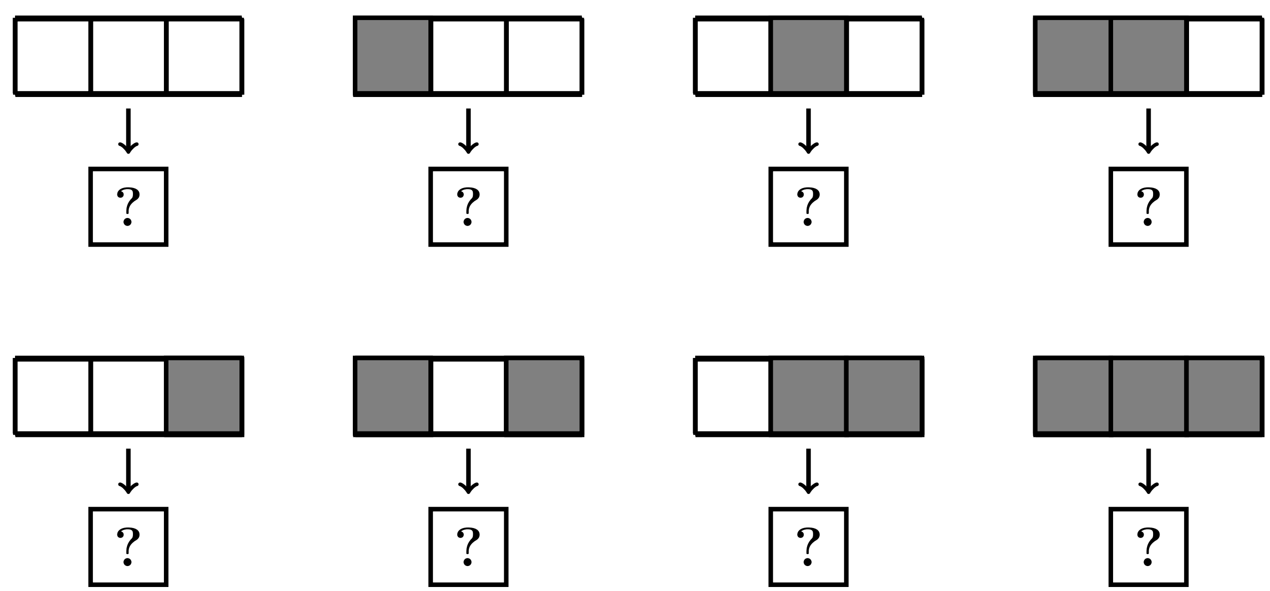
Egy dimenziós sejtautomata:



Egy sejt környezete:



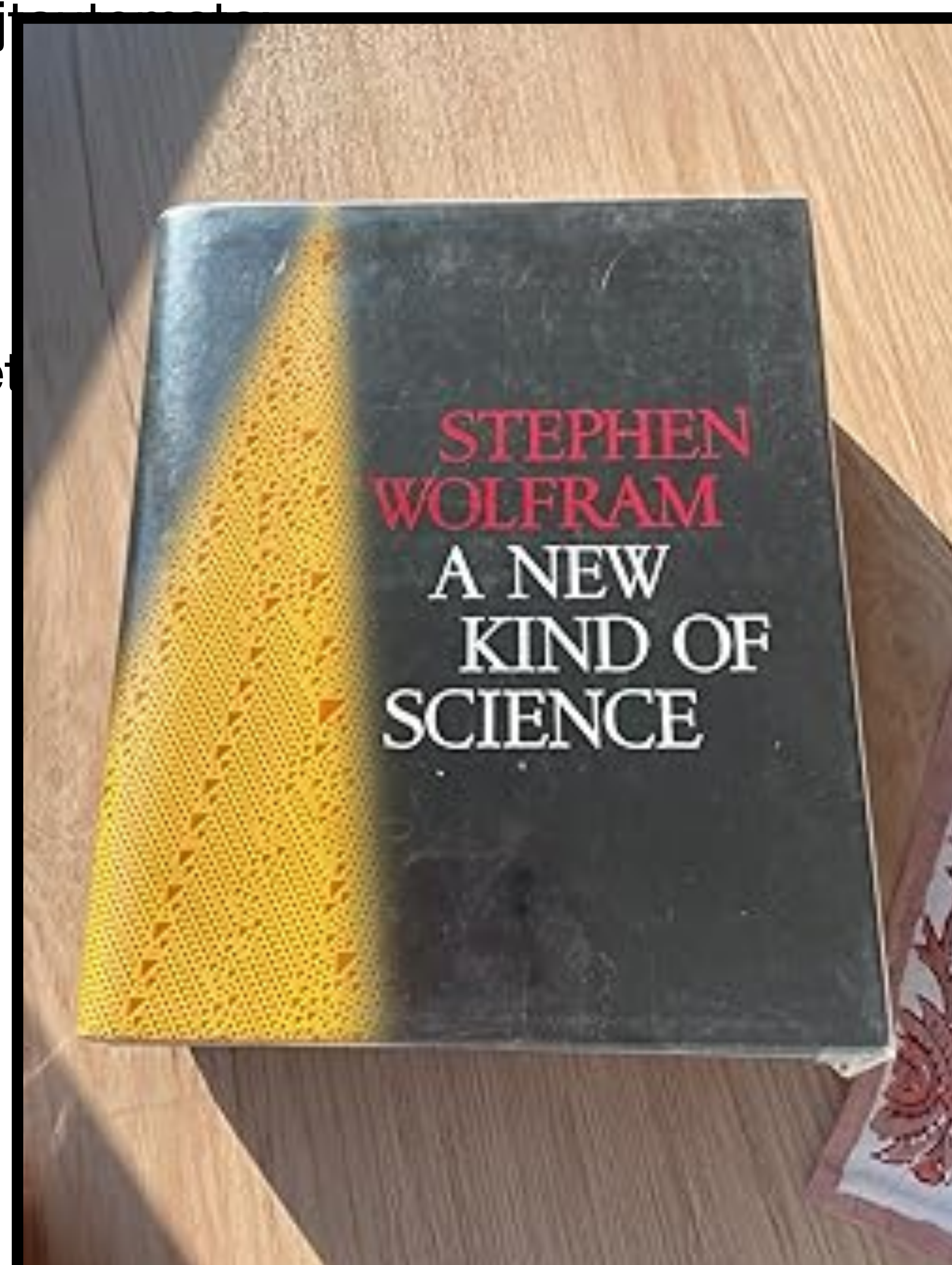
Lehetőségek:



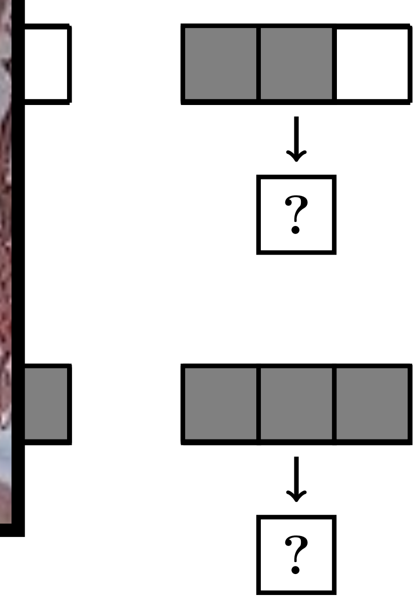
$2^8 = 256$ szabály!

Egy dimenziós sej

Egy sejt környezet

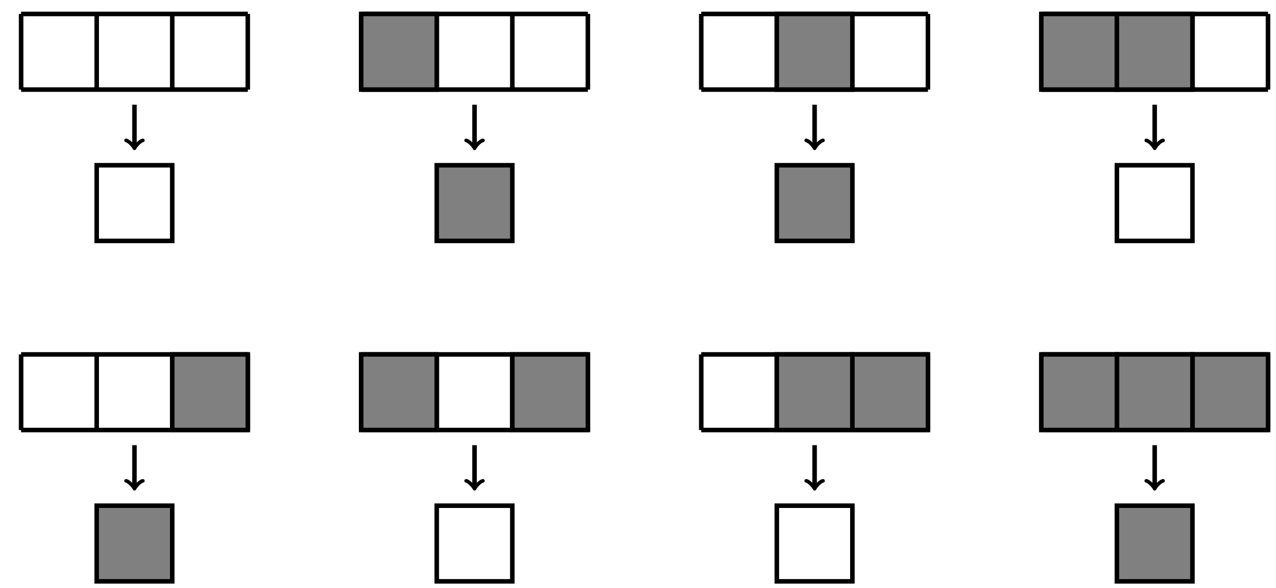


Lehetőségek:



$2^8 = 256$ szabály!

Egy konkrét modell
(150-es modell)



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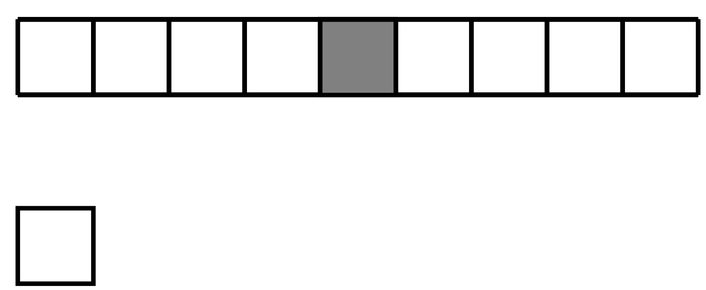

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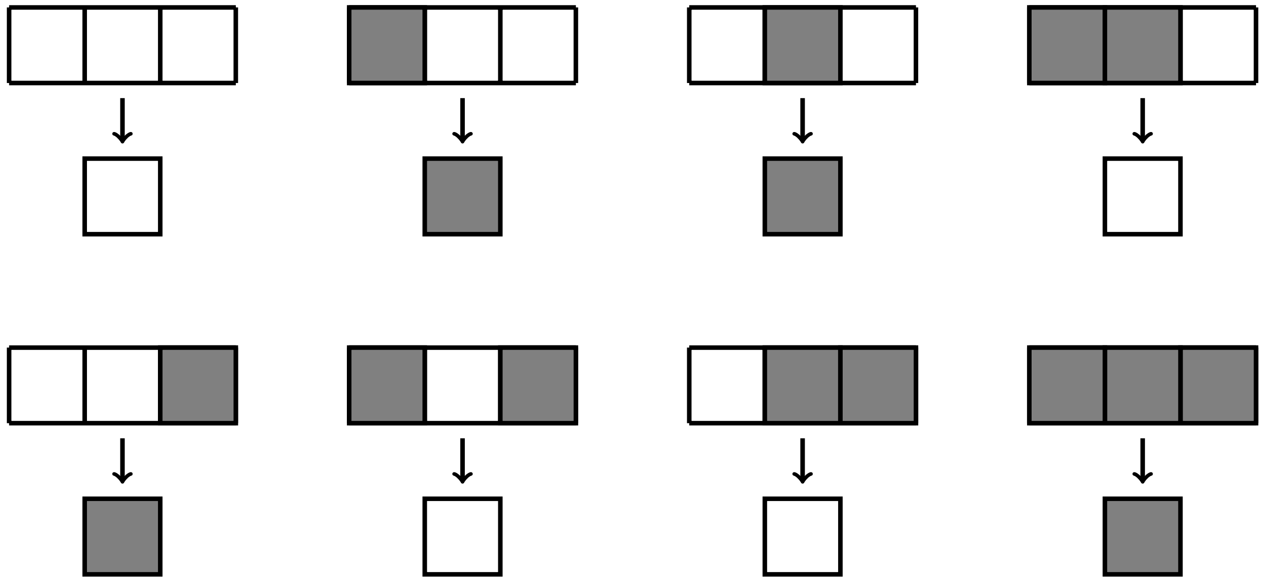

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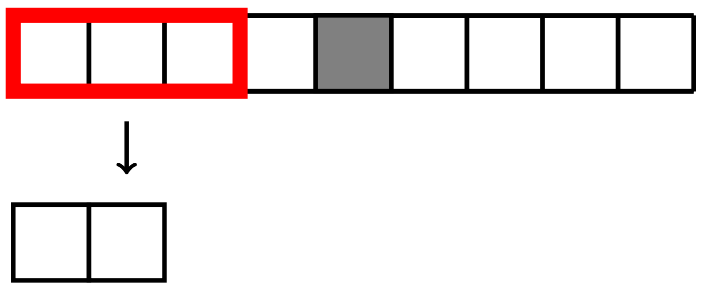

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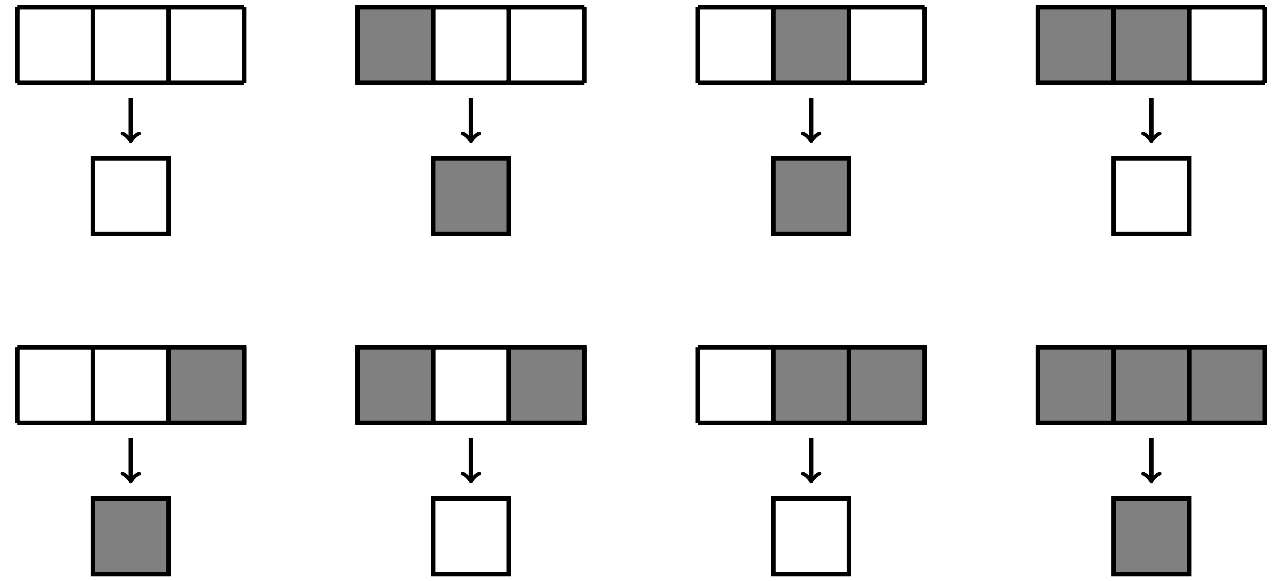

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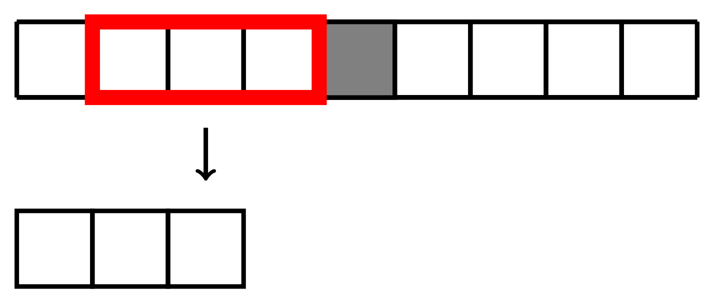

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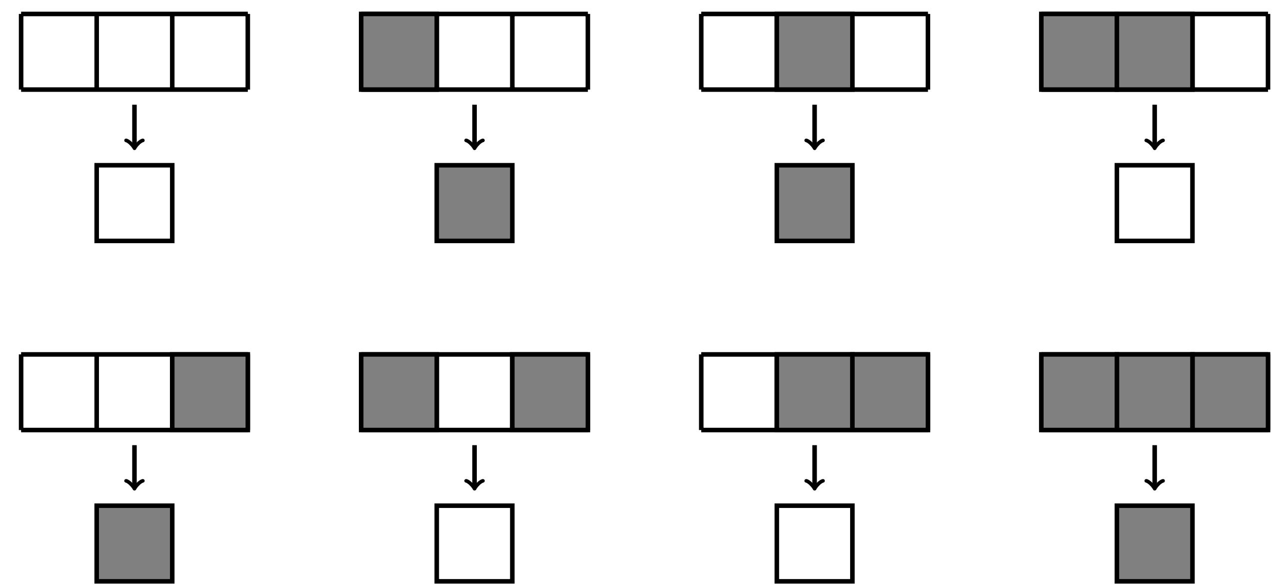

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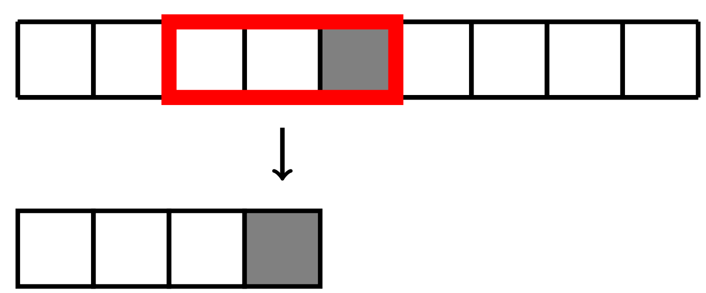

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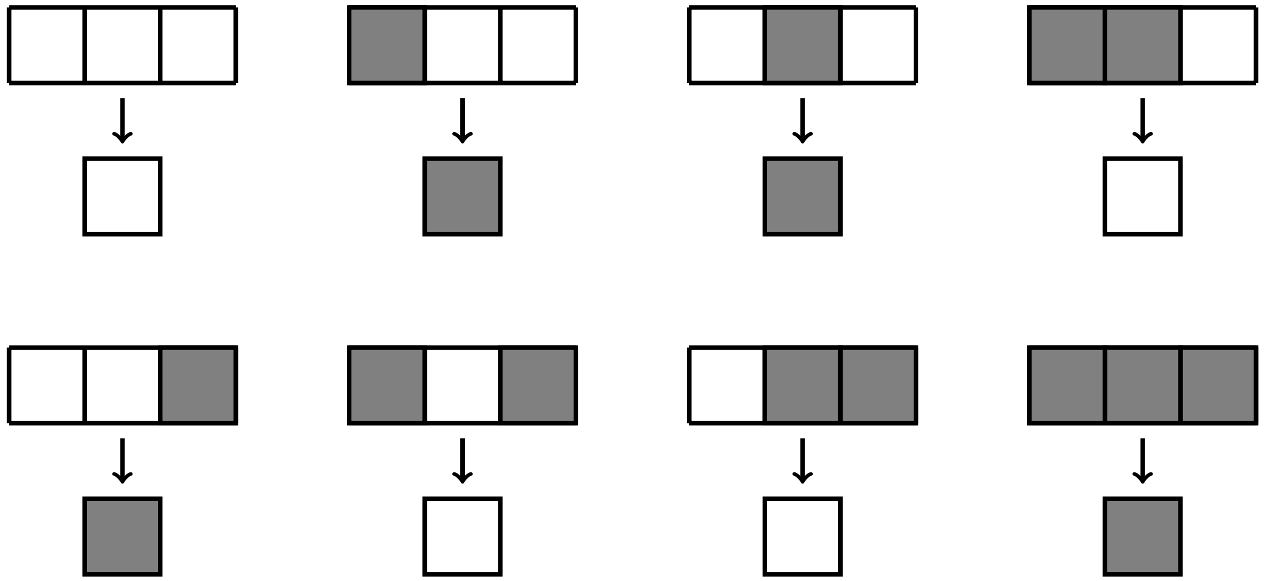

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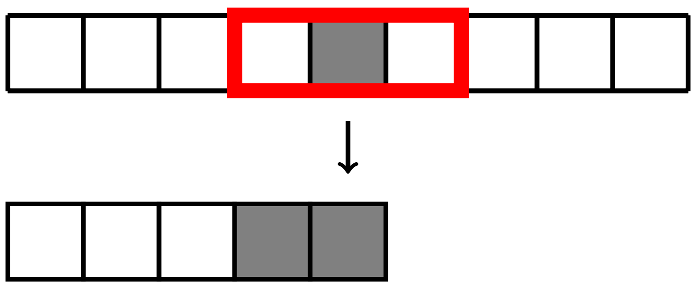

Egy konkrét modell
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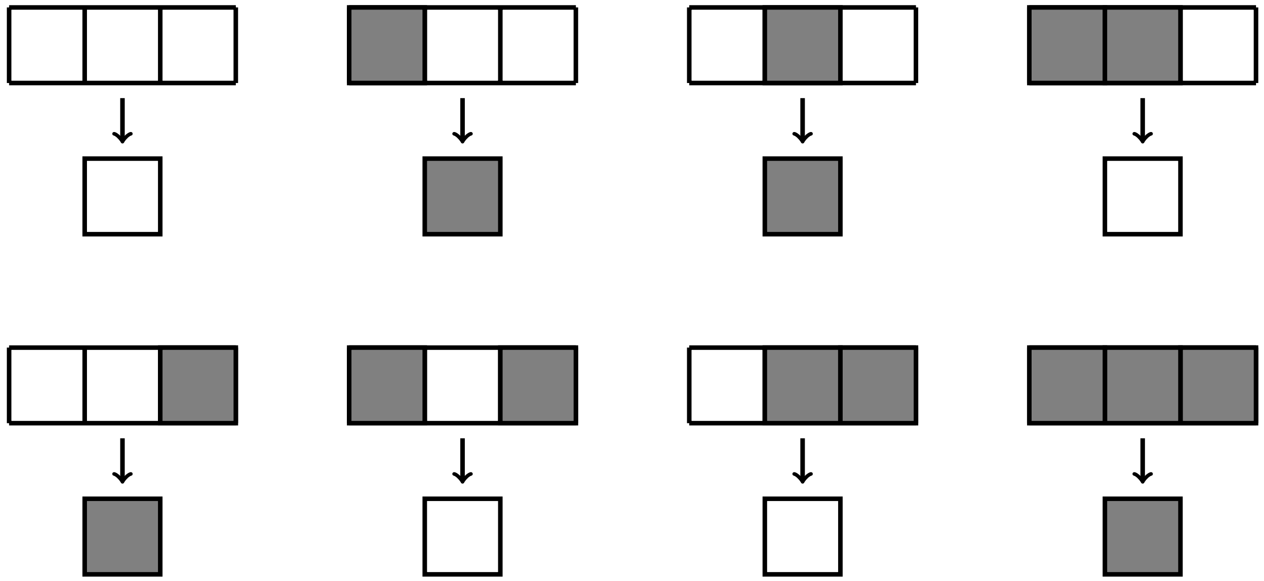

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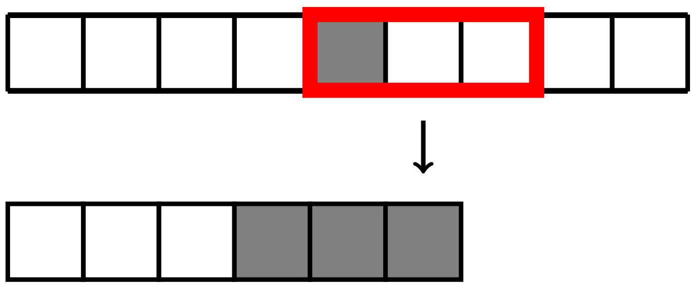

Egy konkrét modell
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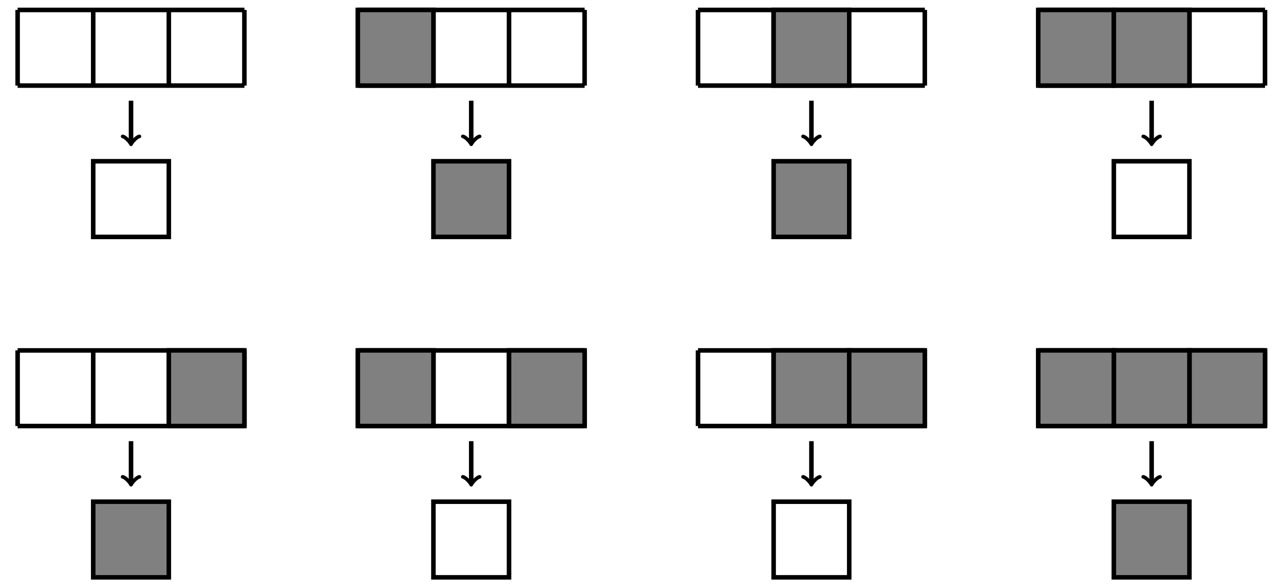

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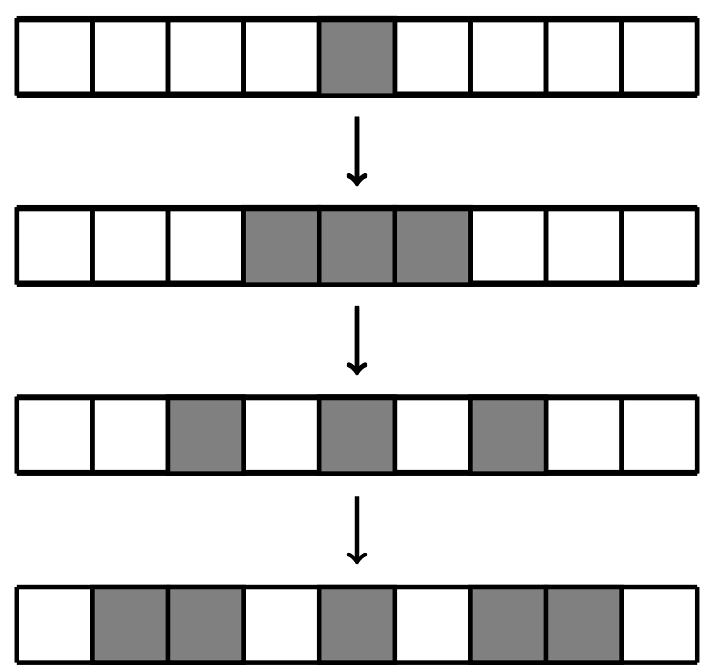
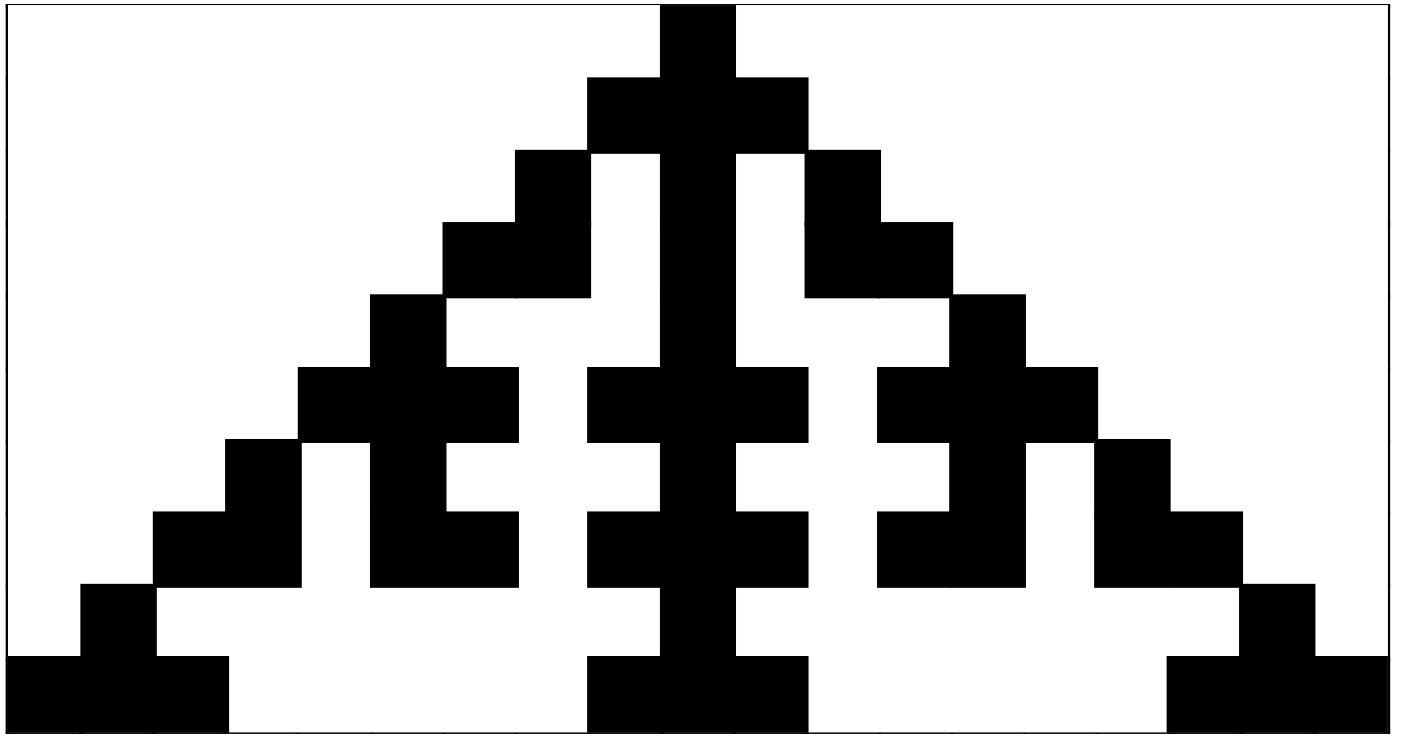


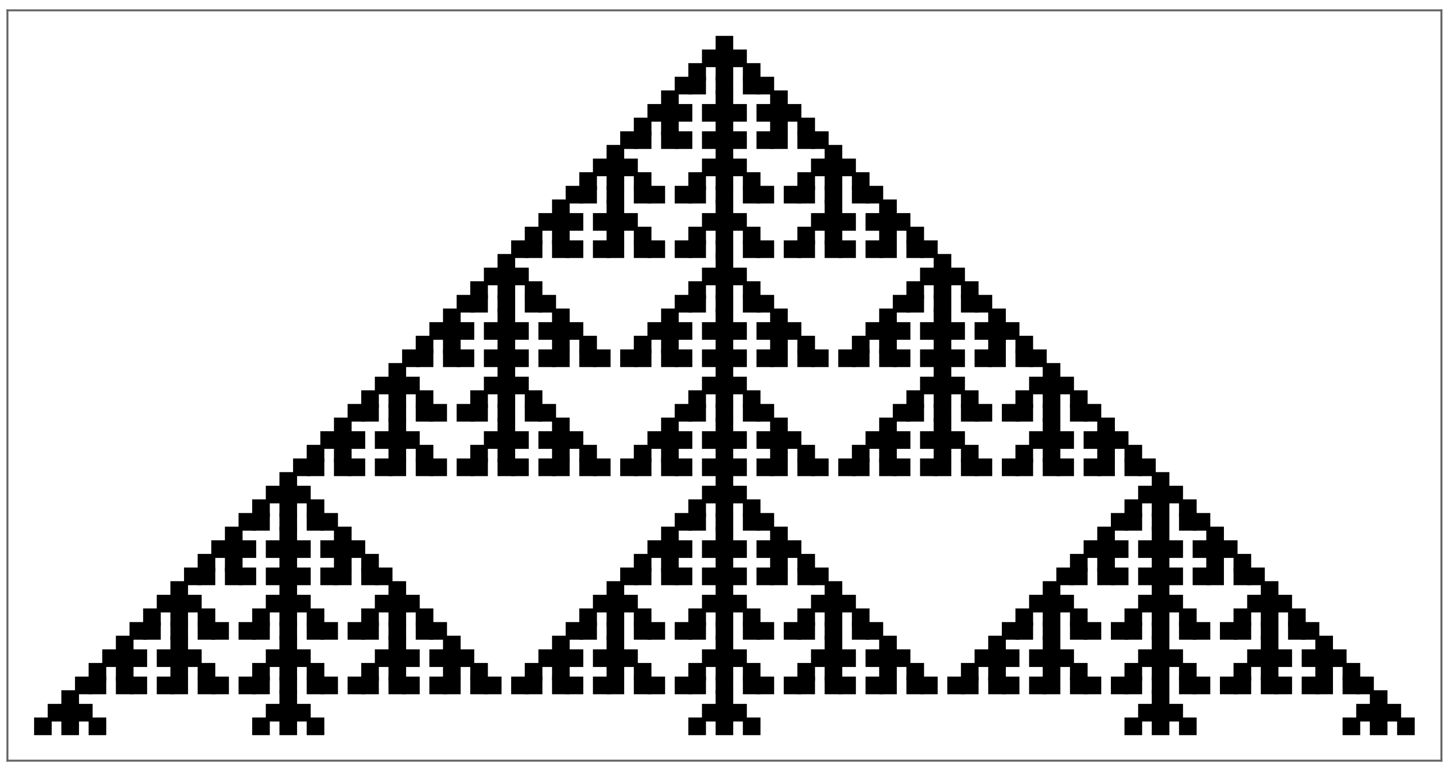
(*Wolfram's Mathematica*)

9 lépés:



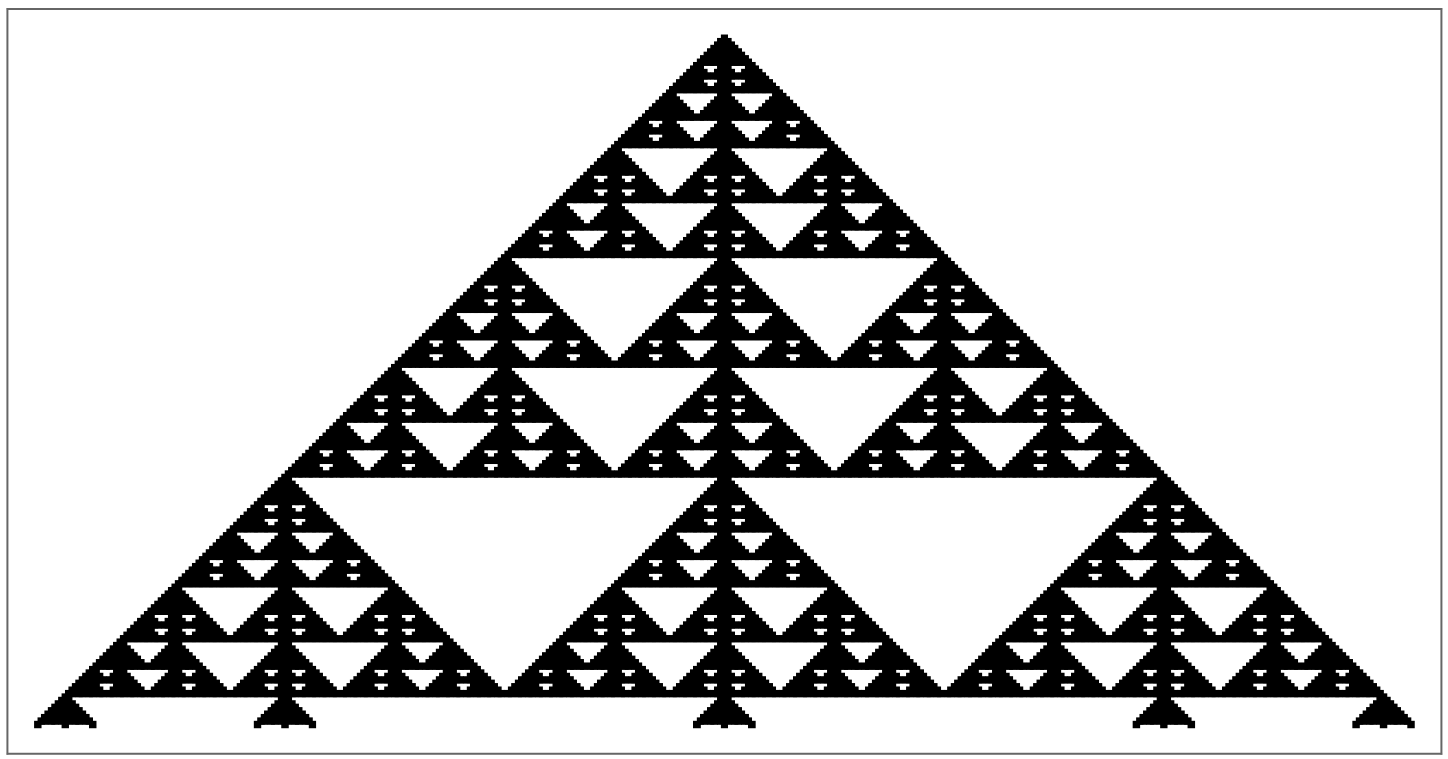
(*Wolfram's Mathematica*)

50 lépés:

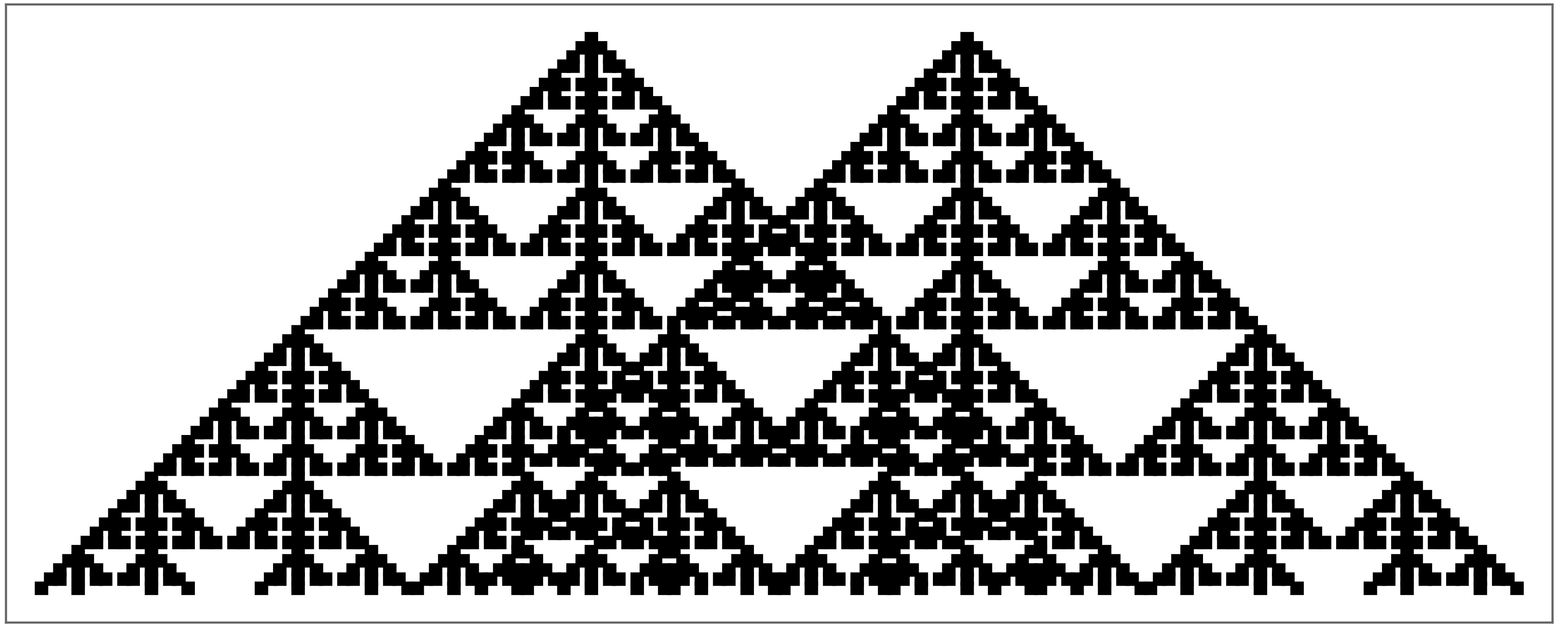


(*Wolfram's Mathematica*)

200 lépés:

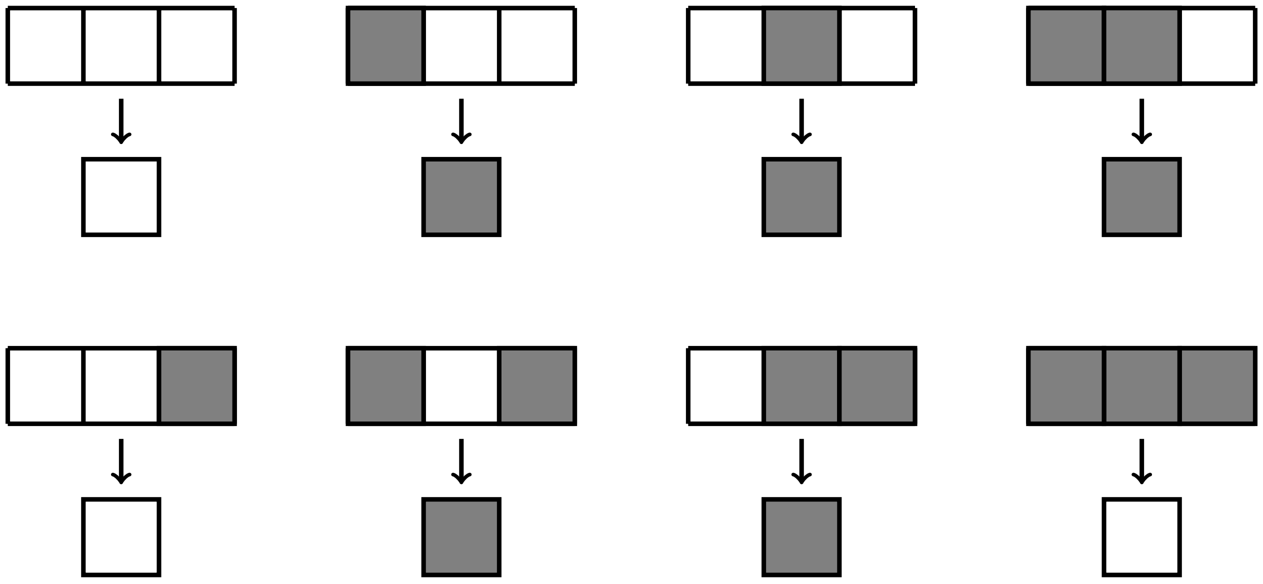


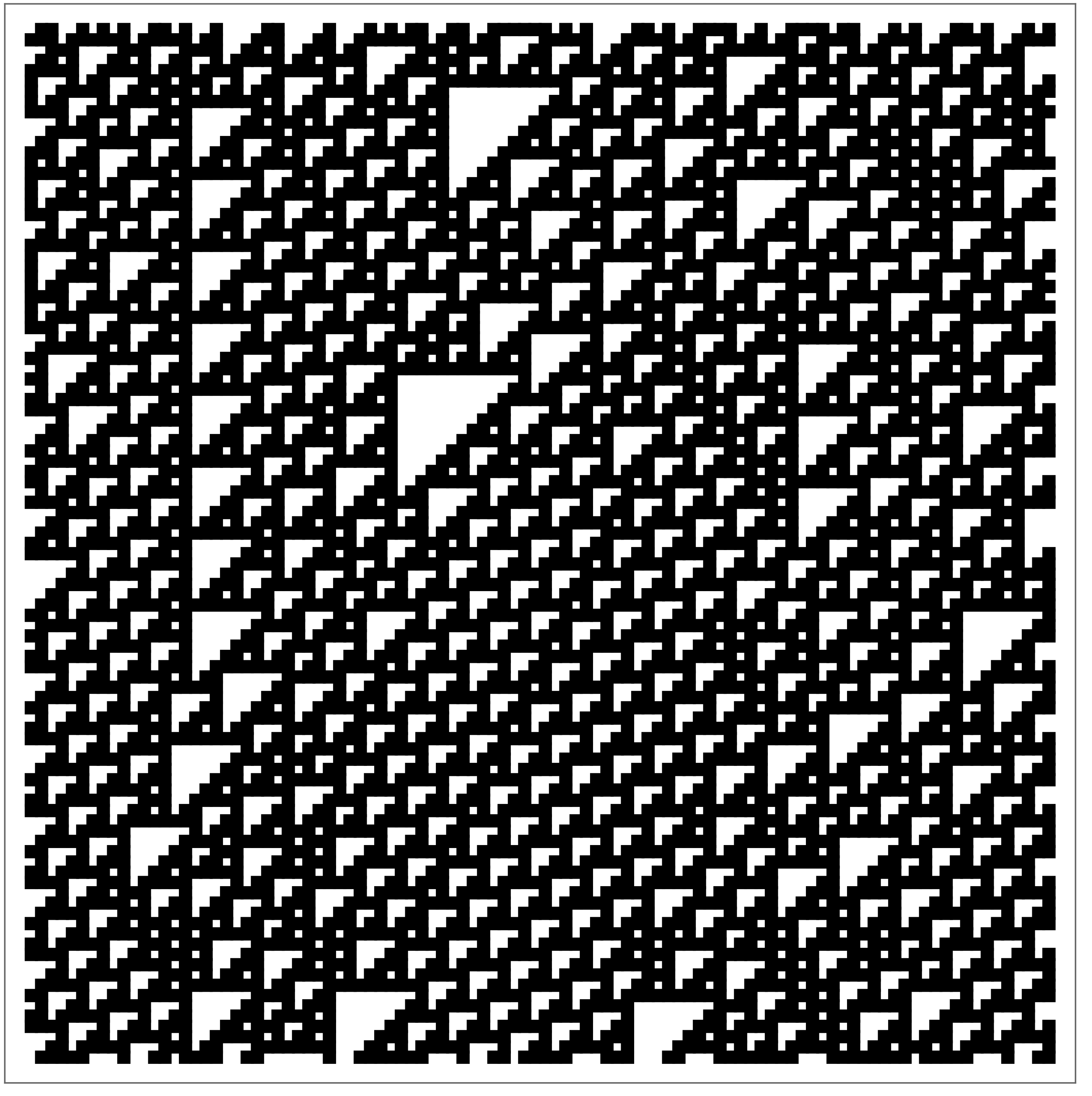
Két aktív sejtből:



Véletlen konfigurációból:

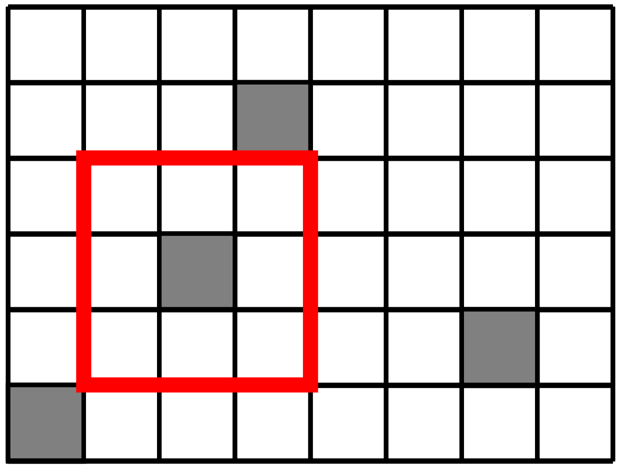
Másik konkrét modell: (110-es modell)



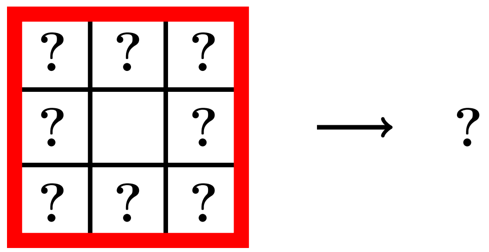


Turing-teljes!

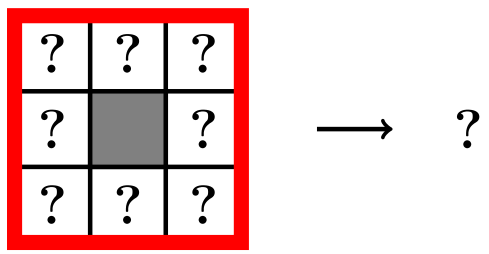
Sejtautomaták két dimenzióban:



John Horton Conway: Game of Life

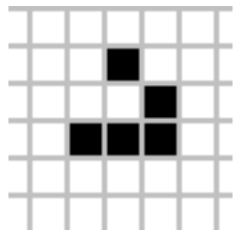


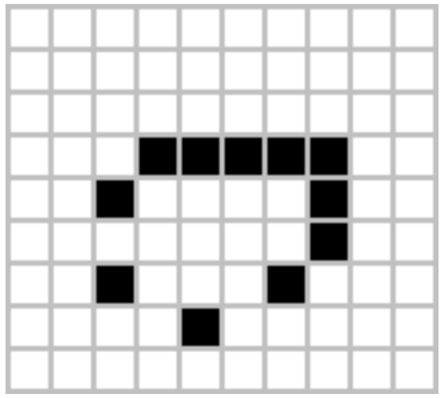
Az inaktív aktívvá válik,
ha pontosan 3 aktív szomszédja van.

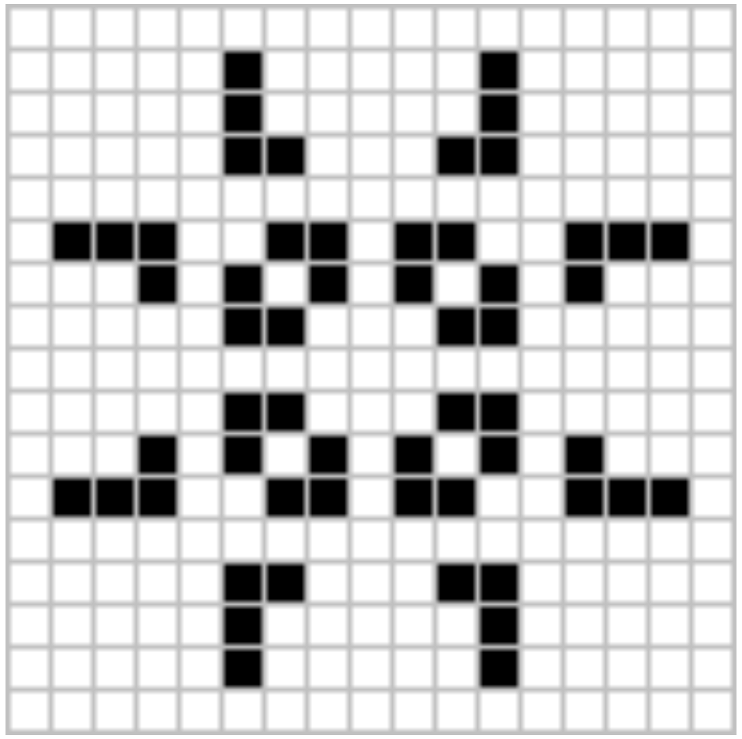


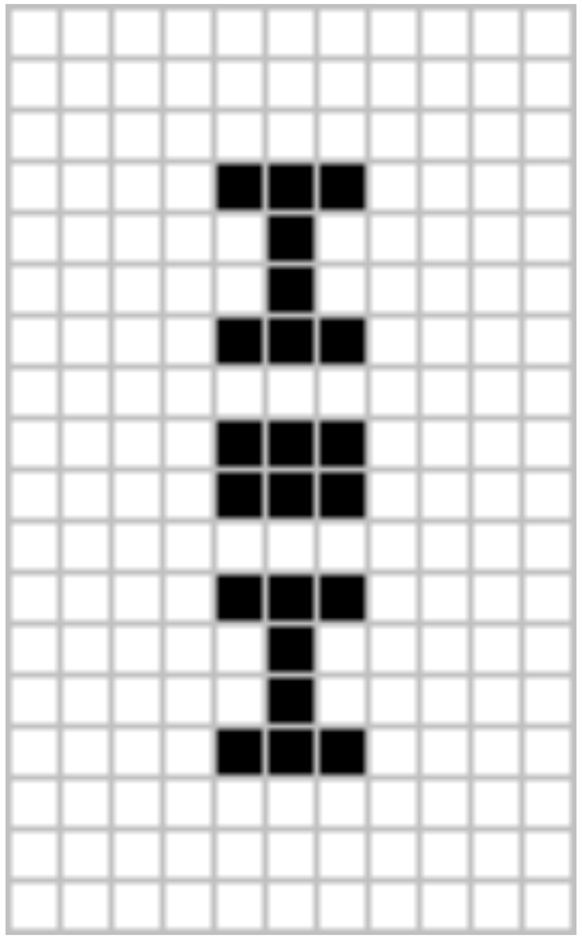
Az aktív az aktív marad,
ha 2 vagy 3 aktív szomszéda van.

(wikipedia, Conway's Game of Life)



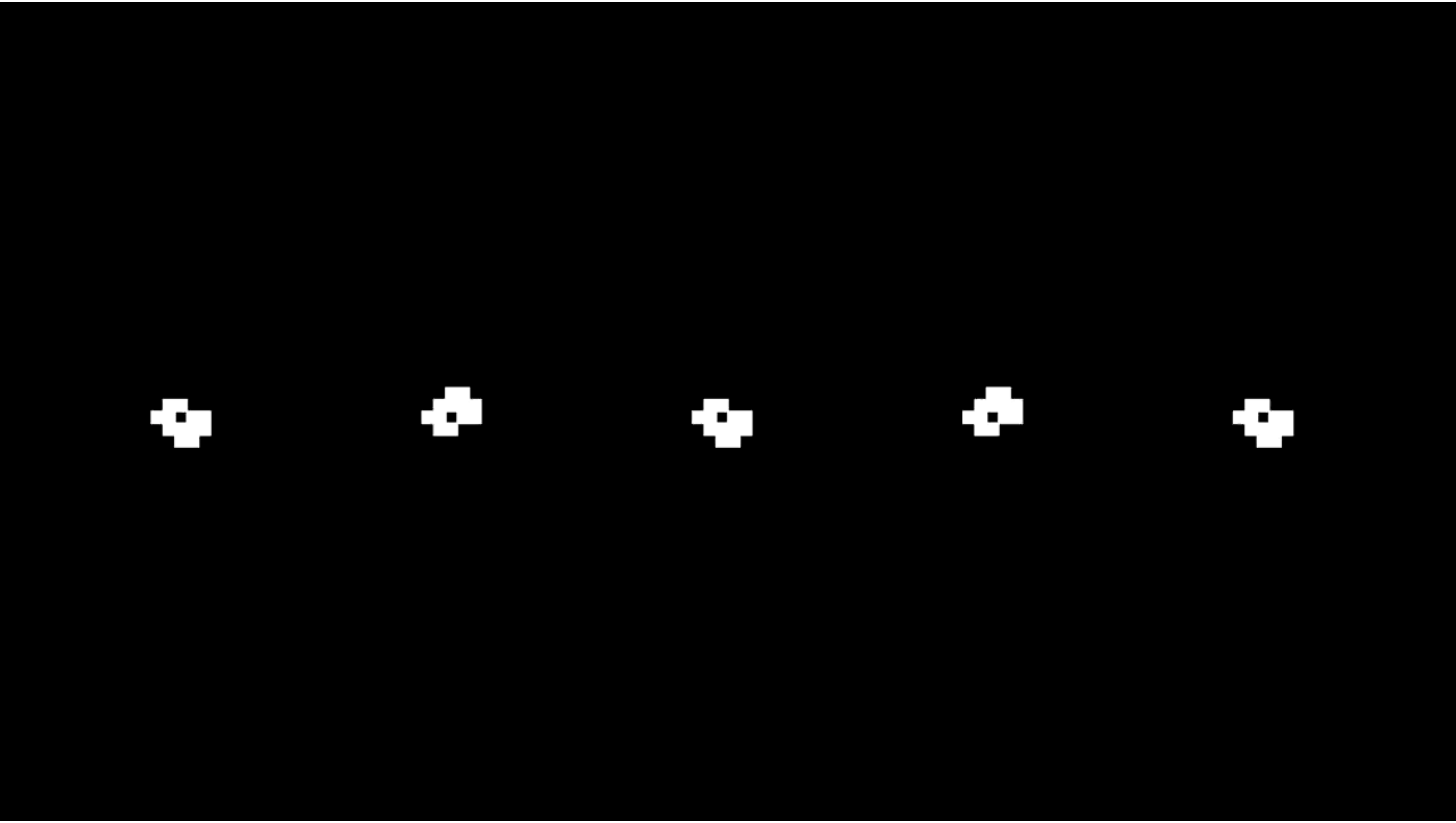






(wikipedia, Conway's Game of Life)

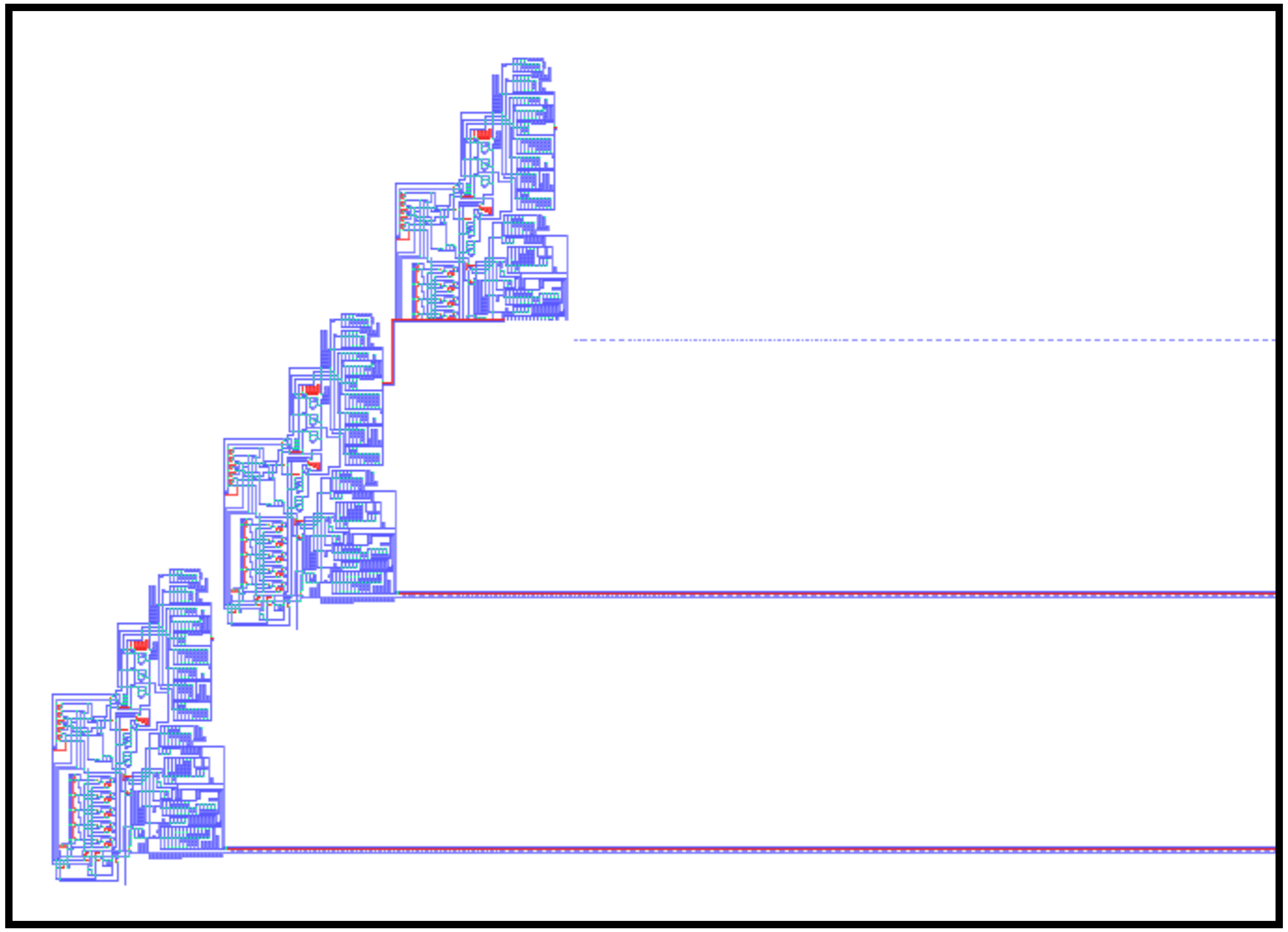
Life in Life, Phillip Bradbury, https://www.youtube.com/watch?v=xP5-iIeKXE8



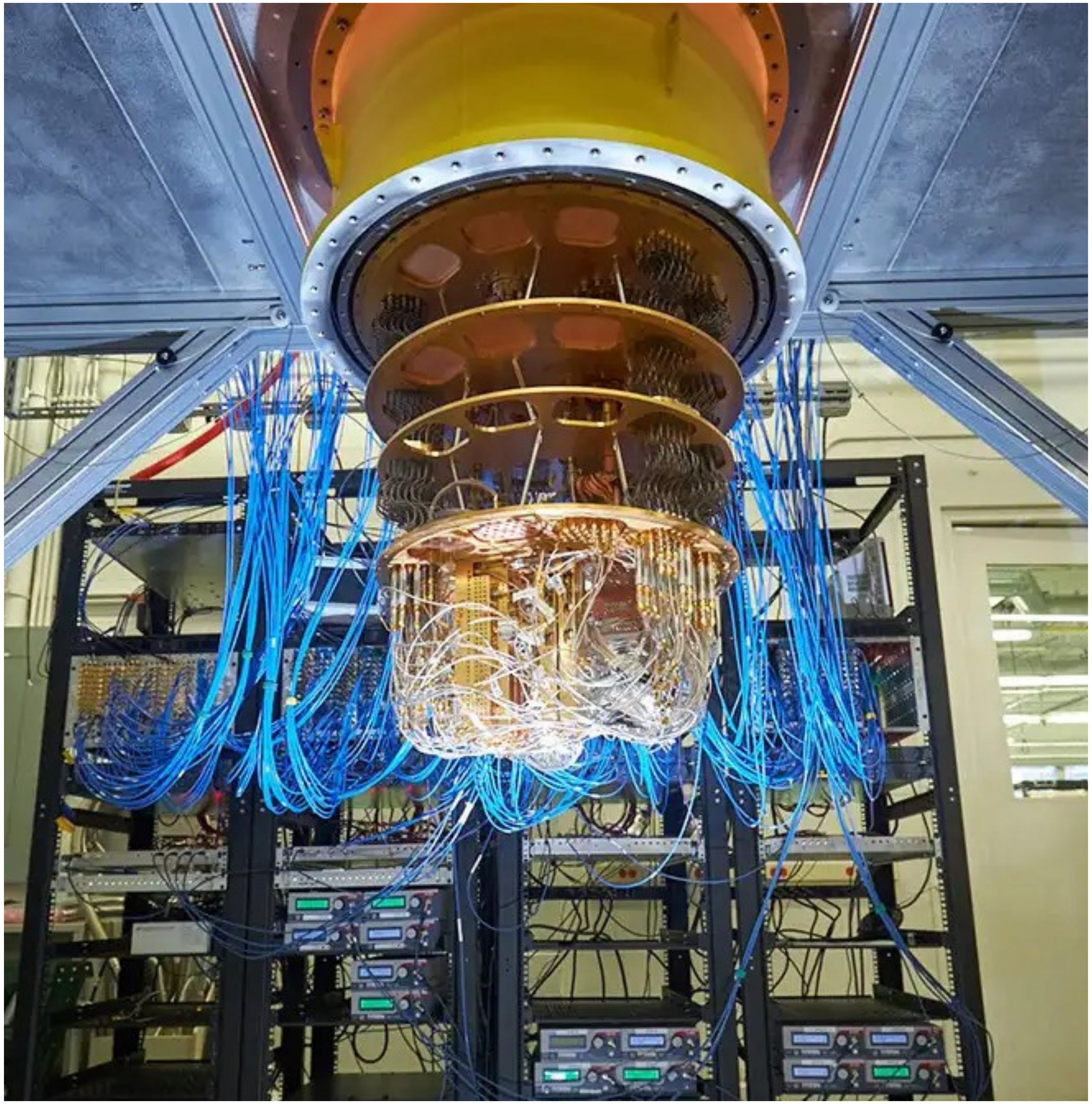
Neumann János, 1903-1957

https://en.wikipedia.org/wiki/Von_Neumann_universal_constructor

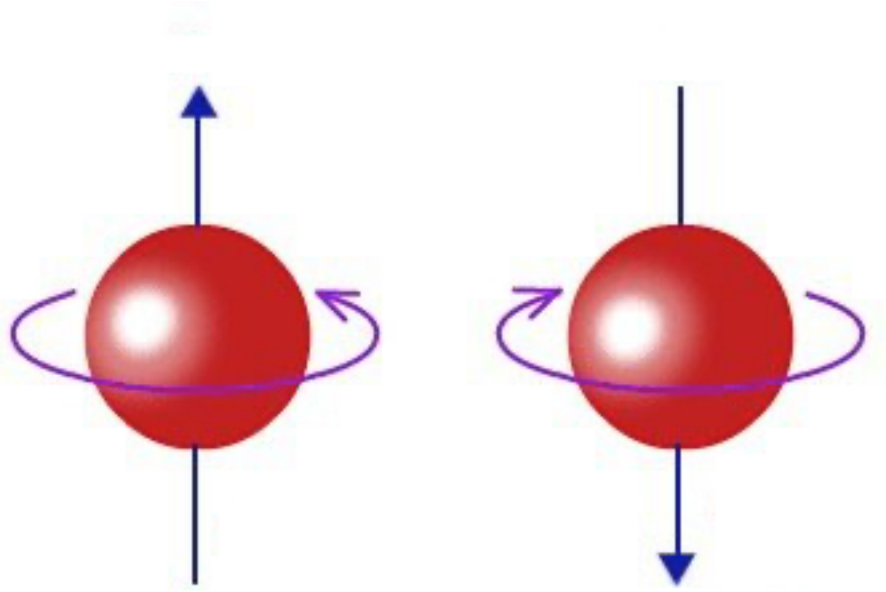
To define his machine in more detail, von Neumann invented the concept of a cellular automaton. The one he used consists of a two-dimensional grid of cells, each of which can be in one of 29 states at any point in time. At each timestep, each cell updates its state depending on the states of the surrounding cells at the prior timestep. The rules governing these updates are identical for all cells.

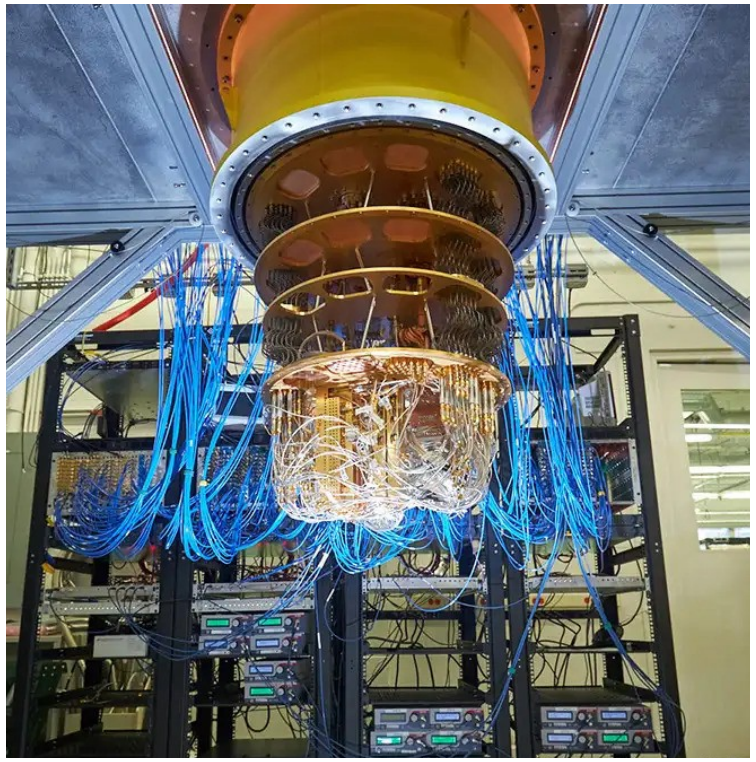


Kvantumszámítógépek?

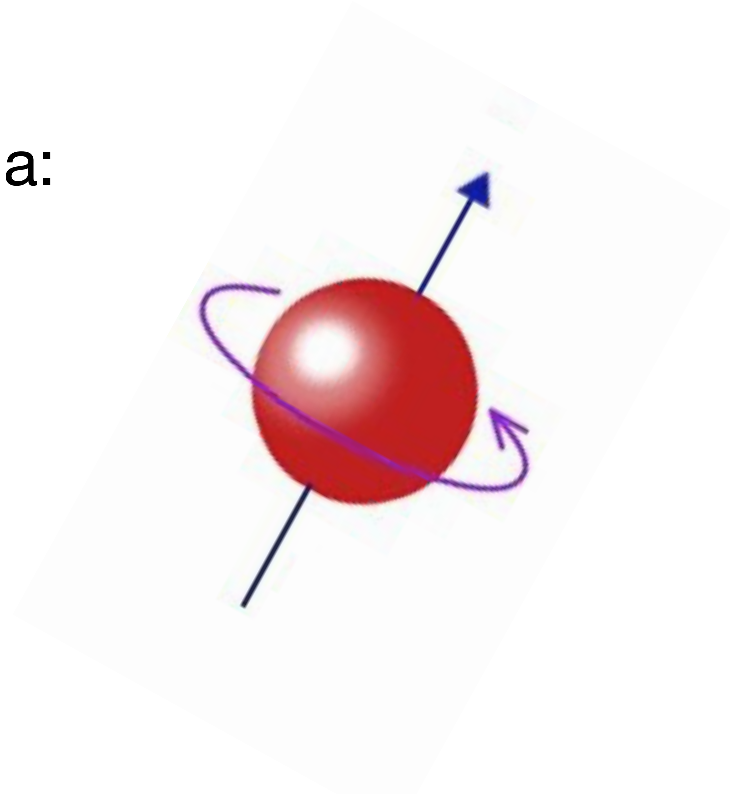


Kvantumbitek: 0 vagy 1



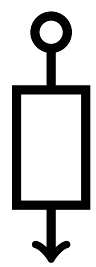


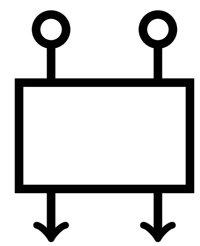
0 és 1 valamilyen szuperpozíciója:

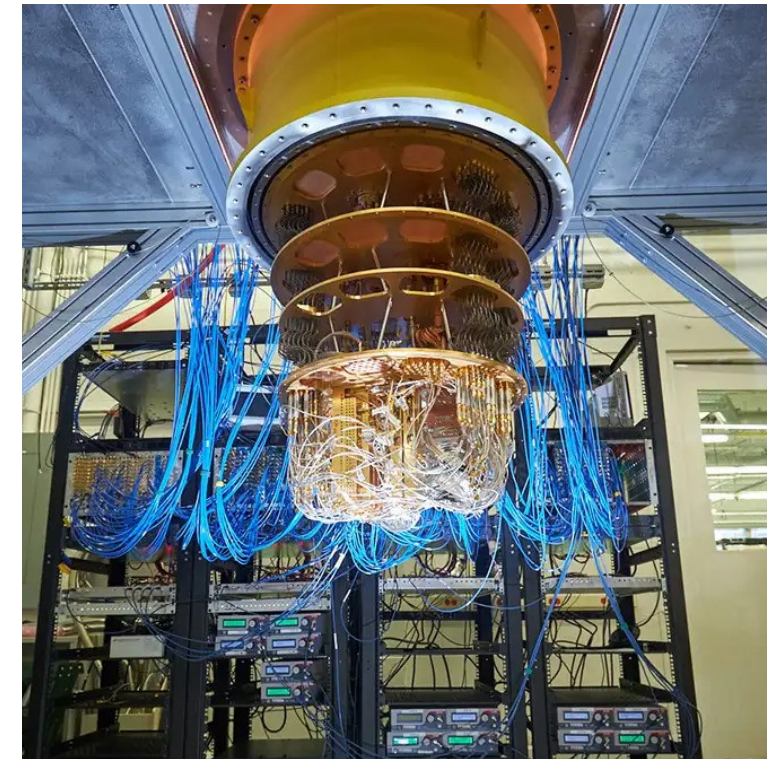


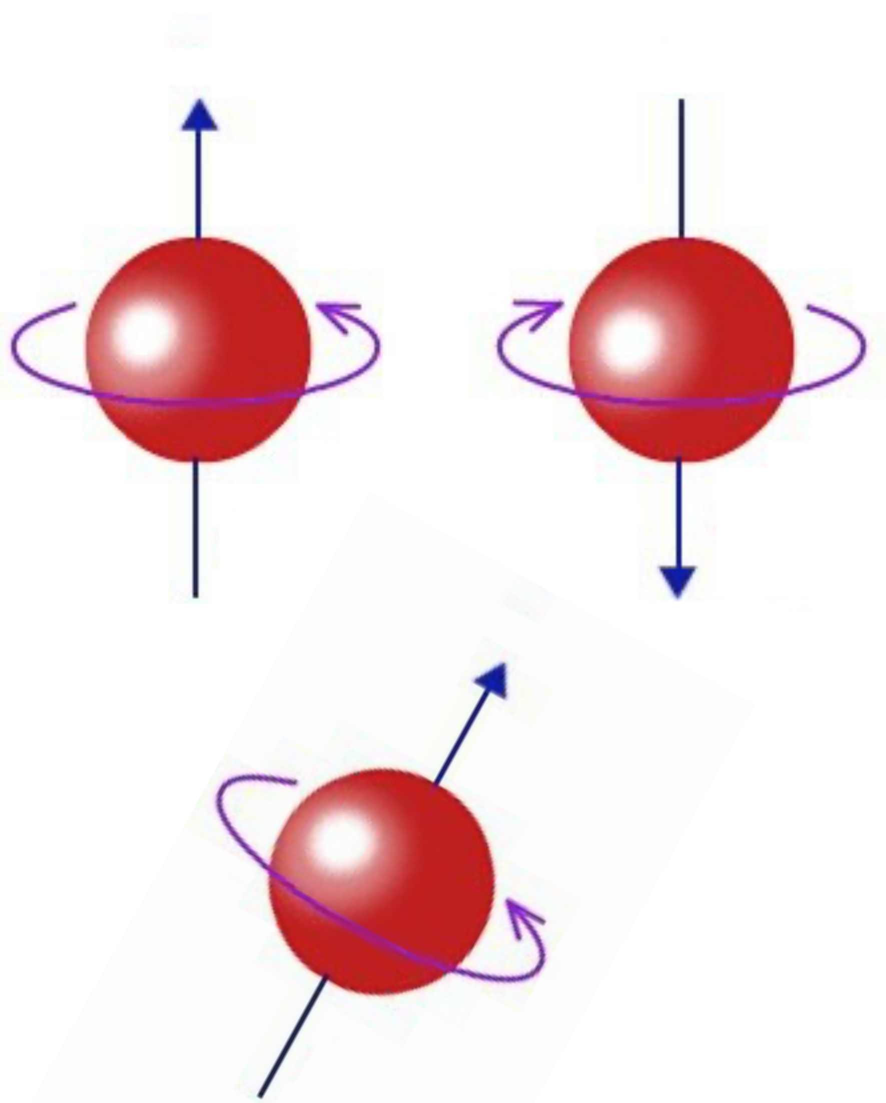
Két kvantumbit: 00, 01, 10 és 11 szuperpozíciója

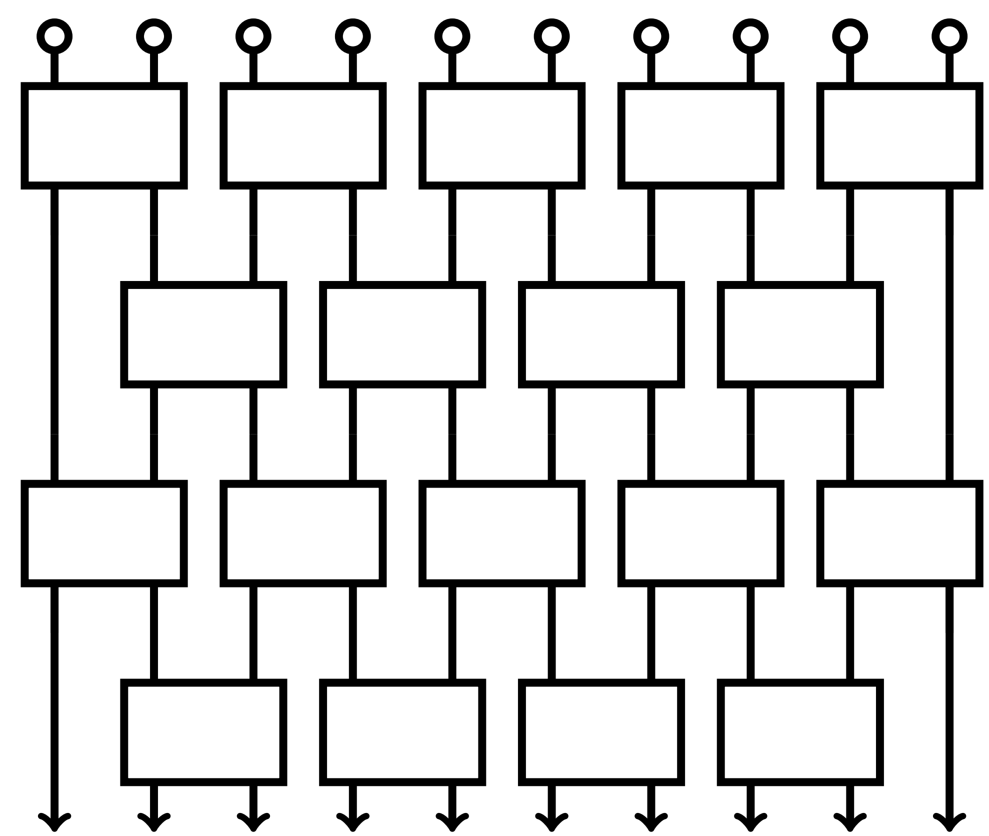
Kvantumbitek: 0 vagy 1





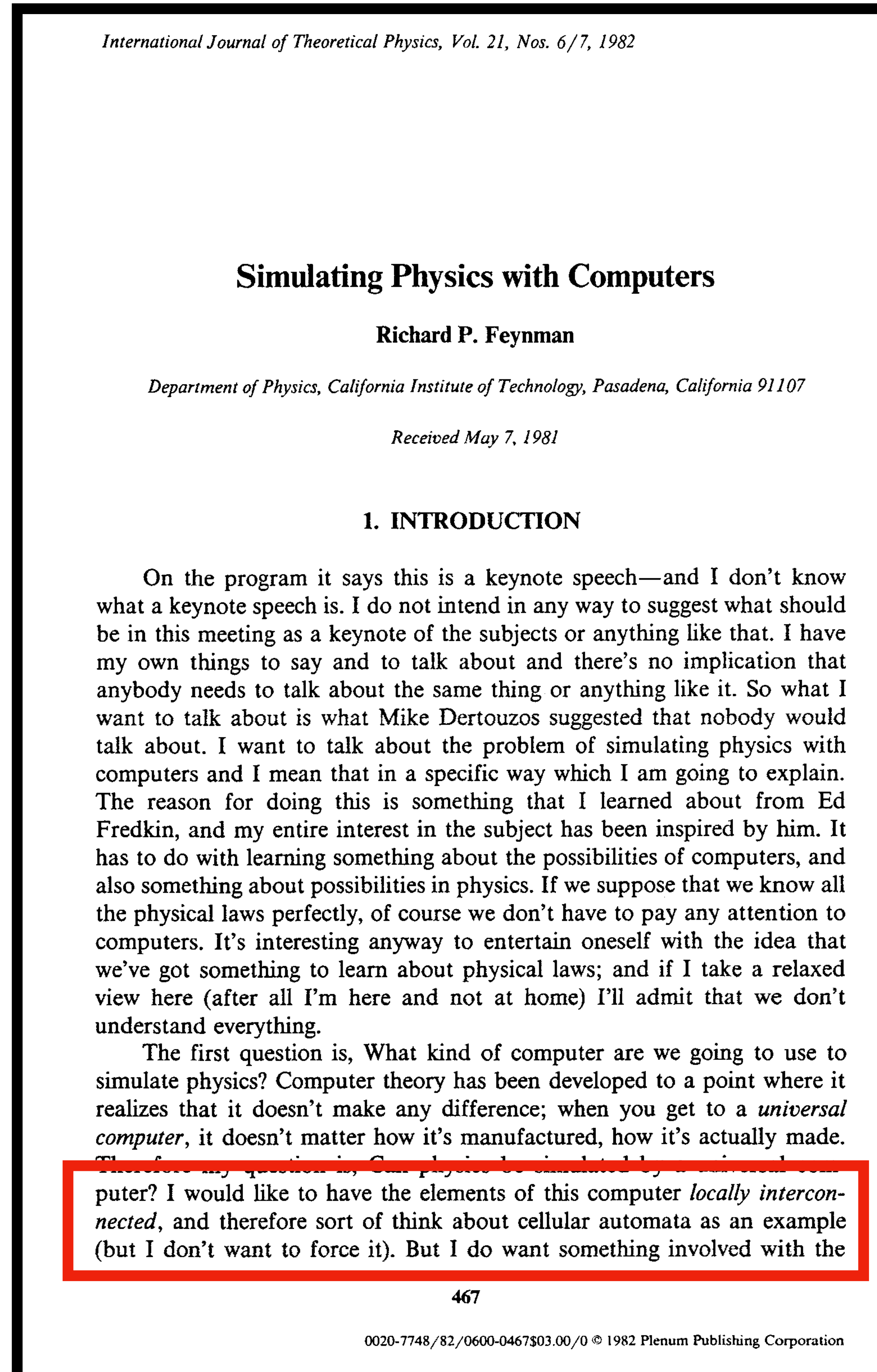






Richard Feynman

,, …nature isn't classical, dammit, and if you want to make a simulation of nature, you'd better make it quantum mechanical, and by golly it's a wonderful problem, because it doesn't look so easy”



International Journal of Theoretical Physics, Vol. 21, Nos. 6/7, 1982

Simulating Physics with Computers

Richard P. Feynman

Department of Physics, California Institute of Technology, Pasadena, California 91107

Received May 7, 1981

1. INTRODUCTION

On the program it says this is a keynote speech—and I don't know what a keynote speech is. I do not intend in any way to suggest what should be in this meeting as a keynote of the subjects or anything like that. I have my own things to say and to talk about and there's no implication that anybody needs to talk about the same thing or anything like it. So what I want to talk about is what Mike Dertouzos suggested that nobody would talk about. I want to talk about the problem of simulating physics with computers and I mean that in a specific way which I am going to explain. The reason for doing this is something that I learned about from Ed Fredkin, and my entire interest in the subject has been inspired by him. It has to do with learning something about the possibilities of computers, and also something about possibilities in physics. If we suppose that we know all the physical laws perfectly, of course we don't have to pay any attention to computers. It's interesting anyway to entertain oneself with the idea that we've got something to learn about physical laws; and if I take a relaxed view here (after all I'm here and not at home) I'll admit that we don't understand everything.

The first question is, What kind of computer are we going to use to simulate physics? Computer theory has been developed to a point where it realizes that it doesn't make any difference; when you get to a *universal computer*, it doesn't matter how it's manufactured, how it's actually made. Therefore my question is, Can physics be simulated by a universal computer? I would like to have the elements of this computer *locally interconnected*, and therefore sort of think about cellular automata as an example (but I don't want to force it). But I do want something involved with the

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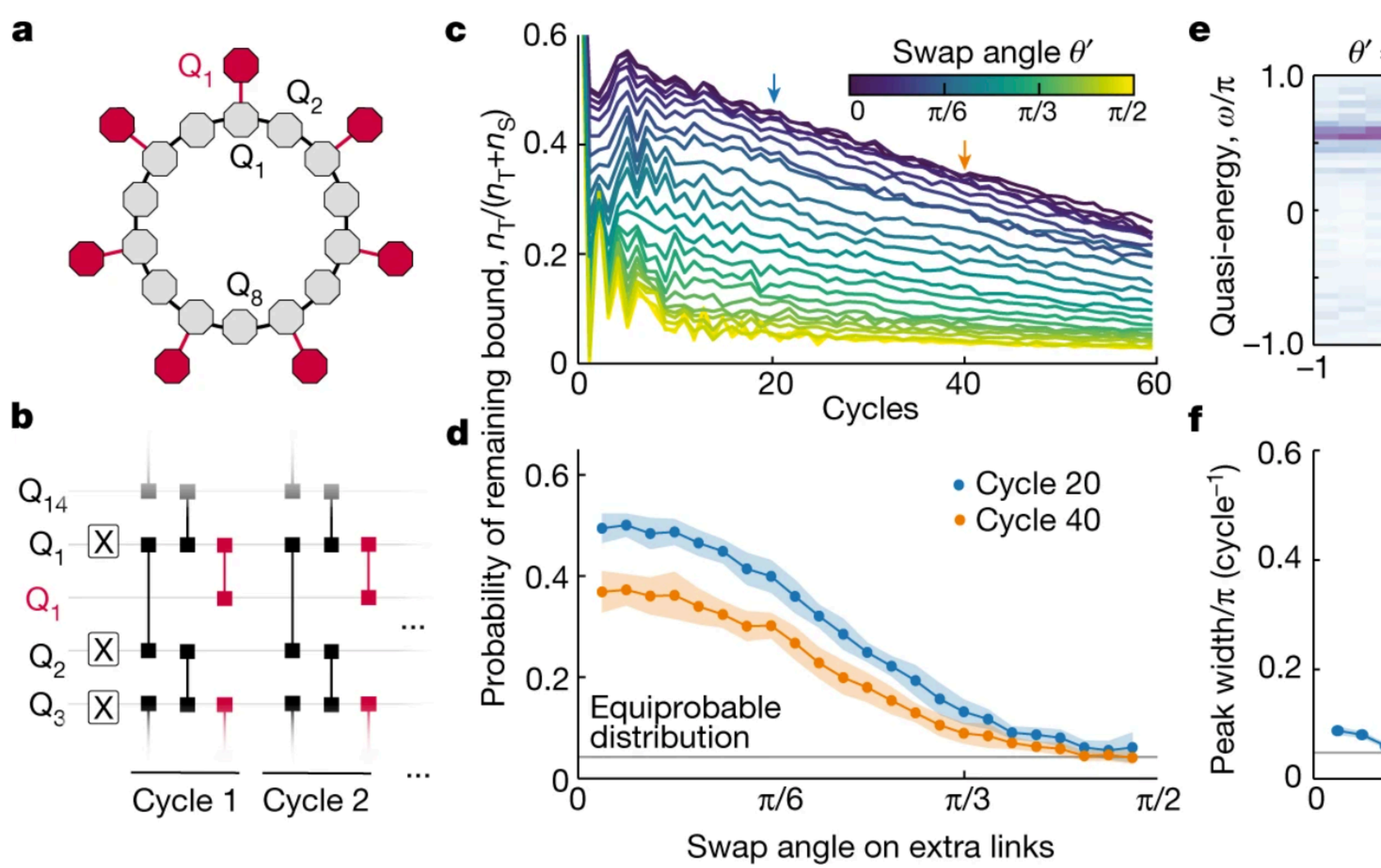
Formation of robust bour microwave photons

A. Morvan, T. I. Andersen, X. Mi, C. Neill, A. Petu
Acharya, F. Arute, K. Arya, A. Asfaw, J. Atalaya, J
Bourassa, J. Bovaird, L. Brill, M. Broughton, B. B
+ Show authors

Nature **612**, 240–245 (2022) | Cite this article

Fig. 4: Resilience to integrability breaking.

From: Formation of robust bound states of interacting microwave photons



a, Schematic of the 14-qubit chain with seven extra sites in red to break the integrability. **b**, Ir between the chain and the extra qubits, with $\phi' = \phi$ and a gradually varied θ'. **c**, Decaying p

Köszönöm a figyelmet!