The Five-Cell R-Pentomino Does Not Settle for 1103 Generations, While the Other Eleven Settle Within Ten

— the R-pentomino grows to **319** cells at generation **821** and settles to **116** cells at generation **1103** — what separates them is shape, not size — [Paper 628]

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— *From thinking to syncing.* —

Abstract

Each cell of an infinite grid is alive or dead, and the next generation is decided by the eight neighbours alone: a live cell survives if 2 or 3 neighbours are alive, and a dead cell is born if exactly 3 are (Conway's Game of Life).Each of the twelve shapes made of five cells (the pentominoes) is placed alone, and the generations until it settles are counted.No new theorem or law is claimed. First, the R-pentomino does not settle for 1103 generations——the population begins to repeat with period 2 at generation 1103, with 116 cells (agreeing with the known values). The largest population on the way is 319 cells at generation 821. From generation 1103 to 1400 the population stays 116, but the rectangle enclosing the live cells keeps widening from 525 by 501 to 673 by 649 (Section 2). **Second, the other eleven settle within 10 generations——counting the first generation at which the board itself equals the board two generations earlier, the longest, T, takes 10. Five, N, P, U, Y and Z, die out; V and W become 7-cell still lifes; and four, I, L, T and X, become 12-cell oscillators of period 2** (Section 3). **Third, judged by population, V and W come out one generation early——counting the generation at which the population begins to repeat with period 2, nine shapes give the same generation as the shape criterion, and only V and W come out 1 earlier. W has 7 cells from generation 1, but its shape changes until generation 2. The population is a shadow of the shape, not the shape itself** (Section 3). **Fourth, and this is the core.With the same five cells, shape splits the lifetimes into within 10 generations and 1103——the rules and the size are the same; only the arrangement of the cells differs** (Section 4). **Keywords**: Game of Life, R-pentomino, cellular automaton, glider, pentomino.

> **Scope of this paper (scope note)**: **No new theorem or law is claimed——the rules of the Game of Life (Conway, introduced by Gardner in 1970), that the R-pentomino settles to 116 cells at generation 1103, and that a glider moves one cell diagonally in 4 generations are all known.Theories such as universal computation are not treated.Why the R-pentomino lasts so long is not asserted——only the generations, populations and spreads are shown.The settled shapes are not named——only their cell counts, and whether each is a still life or a period-2 oscillator, were checked.Relation to earlier papers**: **Paper 621 counted that under the $3n+1$ rule, 27 takes 111 steps and rises to 9232 on the way——here, under a two-line rule, the five-cell R takes 1103 generations and grows to 319 cells on the way.**What is added is **setting all twelve side by side under the same rules**, **matching the shape criterion with the population criterion and finding the two shapes where they differ**, and **placing the separator on shape**.

1. Notation and the Question

Rules: **the neighbours of a cell are the eight cells around it, horizontally, vertically and diagonally. A live cell lives on if 2 or 3 neighbours are alive, and otherwise dies. A dead cell is born if exactly 3 neighbours are alive.**

Two criteria: **the shape criterion takes as the lifetime the first generation at which the board equals the board two generations earlier; from then on it is a still life or a period-2 oscillator. The population criterion takes the first generation at which the number of live cells begins to repeat with period 2 and continues for 100 generations.If something flies away keeping its shape, the shape criterion cannot be used, but the population criterion can.**

Question: **how many generations do the twelve five-cell shapes take to settle?**

2. The R-Pentomino

Computation 2.1: **the R-pentomino (the F shape) was run for 1400 generations.The population begins to repeat with period 2 at generation 1103, with 116 cells. The largest population on the way is 319 cells at generation 821.Both agree with the known values.**

generation	height	width	population
1103	525	501	116
1200	573	549	116
1400	673	649	116

> **Observation 2.2**
>
> **after generation 1103 the population stays 116, but the rectangle enclosing the live cells keeps widening.Something moves away keeping its shape——so the shape criterion cannot be used for the R-pentomino, and the population criterion was used.**

Computation 2.3: **running the five-cell glider for 4 generations returned the same shape shifted one cell diagonally.It is one example of something that moves keeping its shape.**

3. The Other Eleven

Computation 3.1: **each of the other eleven was placed alone, and its lifetime counted by both criteria.**

shape	shape criterion	population criterion	final cells	settled as
I	**6**	**6**	**12**	period-**2** oscillator
L	**9**	**9**	**12**	period-**2** oscillator
N	**5**	**5**	**0**	died out
P	**4**	**4**	**0**	died out
T	**10**	**10**	**12**	period-**2** oscillator
U	**4**	**4**	**0**	died out
V	**3**	**2**	**7**	still life
W	**2**	**1**	**7**	still life
X	**6**	**6**	**12**	period-**2** oscillator
Y	**3**	**3**	**0**	died out
Z	**3**	**3**	**0**	died out

The longest is T, at 10 generations.

Observation 3.2

the population criterion comes out one generation earlier than the shape criterion for V and W.W has 7 cells from generation 1 onward, but its shape changes until generation 2——a settled number does not mean a settled shape. The population is a shadow of the shape.

Observation 3.3

the two criteria give the same generation for nine shapes, and the final cell counts agree for all eleven.The shape criterion never comes out earlier than the population criterion——if the shape repeats every two generations, so does the count.

4. The Separator

Observation 4.1

this is the core: the separator is shape, not size.All twelve have five cells and follow the same rules. Eleven settle within 10 generations, and only the R-pentomino takes 1103——the only difference is how the five cells are arranged.

Observation 4.2

beside Paper 621.In Paper 621, under the $3n+1$ rule, 27 took 111 steps and rose to 9232 on the way——here, under a two-line rule, the five-cell R takes 1103 generations and grows to 319 cells on the way. In both, a short rule does not promise a short journey.

Observation 4.3

what is not said.Why the R-pentomino lasts so long is not asserted, theories such as universal computation are not treated, and the settled shapes are not named——what is shown is the lifetimes of the twelve and where the two criteria agree and differ.

5. Roll Call and Closing

1. **R settles at generation 1103 with 116 cells** (Computation 2.1): **agrees with the known values.**
2. **the largest is 319 cells at generation 821** (Computation 2.1): **from five cells.**
3. **the population stays while the spread grows** (Observation 2.2): **something moves away.**
4. **a glider moves one cell diagonally in 4 generations** (Computation 2.3): **keeping its shape.**
5. **the other eleven within 10 generations** (Computation 3.1): **the longest is T.**
6. **five die out, two become still lifes, four oscillate** (Computation 3.1): **0, 7 and 12 cells.**
7. **V and W come out one generation early by population** (Observation 3.2): **the count is a shadow of the shape.**
8. **final counts agree for all eleven** (Observation 3.3): **two criteria.**
9. **shape separates them** (Observation 4.1): **the core.**
10. **a short rule, a long journey** (Observation 4.2): **Paper 621.**

Closing: **Under the two-line rules of the Game of Life, the five-cell R-pentomino does not settle until generation 1103, grows to 319 cells on the way, and leaves 116 cells.With the same five cells, the other eleven settle within 10 generations——five die out, two become 7-cell still lifes and four become 12-cell oscillators of period 2.The separator is shape, not size.Judged by population, only V and W came out one generation early——a settled count does not mean a settled shape.Placed among the earlier papers——like the detour of 27 in Paper 621, a short rule does not promise a short journey.To be honest——why the R-pentomino lasts so long is not entered, and the names of the settled shapes are not checked.**

References

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