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A Note on the Discovery of a New Game of Three-dimensional Life

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Previously in [1] specific rules for totalistic CA describing games of life in three dimensions were presented. In particular, in the universe of dense-packed spheres (called Ω), the only glider-supporting rule given was $R = (3,3,3,3)$; this rule is described in plain English below. (See [1] for further explanation.) Note that each cell has exactly twelve touching neighbors.

> If a cell (living or dead) touches exactly three live neighbor cells, it becomes (remains) alive next generation; otherwise, it dies.

Recently, a glider has been discovered for the rule $R = (4,6,3,3)$; this rule is stated as (a), (b) below.

> (a) If a living cell has four, five, or six live touching neighbors, it remains alive next generation; otherwise it dies. (b) If a dead cell has exactly three live touching neighbors, it becomes alive next generation.

This rule was investigated somewhat in [2], but no glider was discovered at that time. However, after about 20,000 additional experiments, each of which started with a small random cluster of cells (see [2], page 854), the bizarre glider depicted in figure 1 made its appearance. This glider has twelve phases, each of which is shown along with its signature [2]. Note that after six generations, the form of the object repeats but with a different orientation. The glider moves each complete cycle a distance of $3\sqrt{3}$ in the direction depicted. Note the unusual symmetry (see bottom, figure 1).

A more serious attempt has now been made to find other interesting oscillators for the rule $(4,6,3,3)$. This rule, unlike $R = (3,3,3,3)$ seems to support a large number of period > 2 oscillators; some of them are illustrated in figure 2. The bold numbers give the period and the numbers separated by dashes specify the number of live cells in each phase. As with $R = (3,3,3,3)$, most of the objects discovered exhibit symmetry of some form. One should note that many period $= 2$ oscillators exist; they simply have not been illustrated. Stable forms, however, appear to be rather rare.

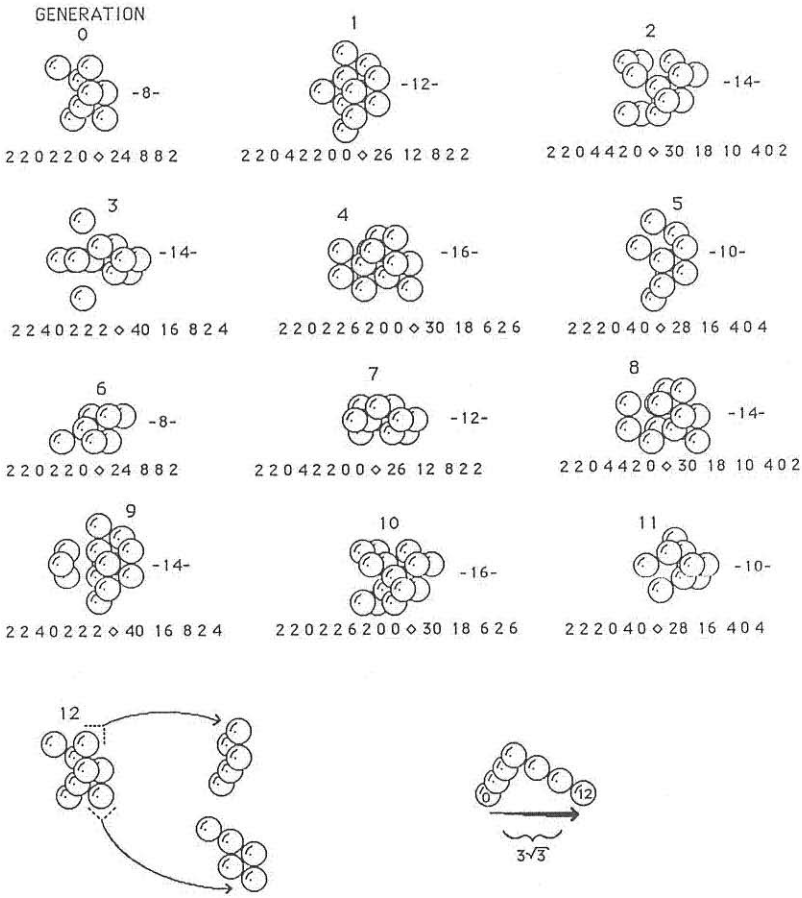

Figure 1: The twelve phases for the $(4, 6, 3, 3)$ glider are illustrated along with the signatures for each. Note that after six phases, the forms repeat, but at a different orientation. Each of the phases exhibits a rather difficult to observe "intersecting-twisting" symmetry (see bottom left). After twelve generations, the glider has moved a distance of $3\sqrt{3}$ in the direction shown (see bottom right—the number in the sphere depicts the relative position of a cell at generation zero and at generation twelve).

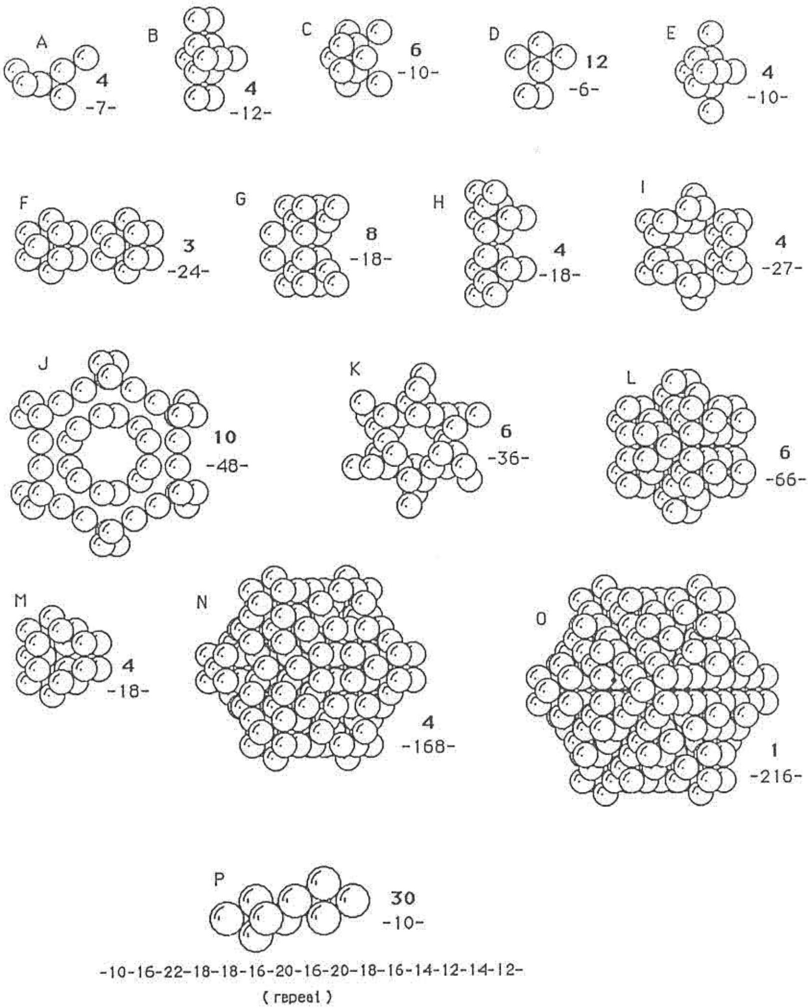

Figure 2: Here are a few of the more interesting oscillators for $R = (4,6,3,3)$ with a period > 2. For each of the above forms, the bold number gives the period and the numbers separated by dashes give the number of cells in the phase illustrated. Depending upon the oscillators, this number may vary from phase to phase. Stable forms are rare; one is illustrated at the lower right. For the period 30 oscillator at the bottom, the size of each phase is given. The forms repeat after 15 generations, but with a different orientation.

It should be pointed out that $R = (4, 6, 3, 3)$ appears to allow unbounded growth. It is, however, extremely difficult to force finite primordial blobs to exhibit such growth; nevertheless, in the strict sense of the definition for a game of Life given in [1], $R = (4, 6, 3, 3)$ falls somewhat short. But since gliders for totalistic three-dimensional rules are so rare (three known in Ω), and since unbounded primordial growth under $R = (4, 6, 3, 3)$ is quite difficult to attain, the three-dimensional Life rule $R = (4, 6, 3, 3)$ is probably "worthy of the name."

References

[1] Carter Bays, "Candidates for the Game of Life in Three Dimensions," *Complex Systems*, **1** (1987) 373–400.

[2] Carter Bays, "Stable and Oscillating Patterns for Simple Cellular Automata in a Universe of Dense-packed Spheres," *Complex Systems*, **1** (1987) 853–875.