Rerum Naturalium Fragmenta
No. 481

Tamas Jasko

Degrees of connectedness
in Conway's life, I.

Introduction
Degrees 1-10

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Rerum Naturalium Fragmenta

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Introduction

Still life forms in Conway's life can be classified as simple (connected), pseudo and quasi life forms and by extension of this concept we arrive at constellations. These classes differ in the degree of connectedness, that is, the neighbourhood, that covers the (complete) life form.

Polyominoes, polyplats, disconnected (strict) life forms, pseudo and quasi life and, finally, constellations, form a series from closely connected to unconnected, and distant. These stages can be numbered from 1, 2, and so on.

Let us designate as degree 1, the polyominoes, where every cell is connected with every other cell rook-wise, so the cells are Neumann connected.

Degree 2 then belongs to polyplats, where every cell is connected with every other cell either rook-wise or bishop-wise, so the cells are Moore connected.

Cells adjacent to the sides of a life form constitute its Neumann neighbourhood. Cells adjacent to the sides or corners of a life form constitute its Moore neighbourhood. This one layer neighbourhood can be joined to the form and then a second layer of neighbourhood can be defined, and added, and so on, forming a set of onion shells, in each odd stage the existing

shell is added to at the sides, then, in the next even stage, completed by adding cells at the corners.

With the help of these neighbourhoods the numbering of degrees can be extended. A form of disconnected live cells is of odd degrees when you have to add the n-th (odd) stage to the shells, so that it becomes connected. In this numbering, the first Neumann neighbourhood counts as 3. The relationship of these degrees with established classes of life forms is shown in the following table.

```
Class/Degree  1    2    3    4    5    6    7    8    9    ...
Polyominoes   ■■■
Polyplats          ■■■
Strict (unconnected) ■■■ ■■■
Pseudo             ■■■
Quasi                        ■■■ ■■■
Constellations               ■■■ ■■■ ■■■ ■■■ ■■■ ■■■ ...
```

Table 1. Degrees of connectedness vs classes of life forms

Examples of each degree are given in the next part, with relative frequency as percentage in random soups. The percentages relate to the number a given form was found in random soups and/or systematic scans, as detailed in my previous paper on odd/even frequencies.

Degree 1 – Polyominoes

There are two life forms only that are polyominoes, rook-wise (Neumann) connected. One is the Block, the most common still life form, 32 % of life in all soups are blocks.

■■
■■

Block (xs4_33)
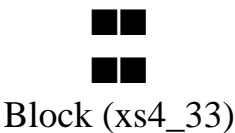
The other is the Blinker, the only oscillating (periodic) life form that is always rook-wise (Neumann) connected. It is the second most common of all life forms, 31 % of life in all soups are blinkers. This way 63% of life forms in soups are of degree 1.

■■■

Blinker (xp2_7)

Another life form, the Toad is rook-wise connected in one of its stages (see below).

Degree 2 – Polyplats

A life form is of degree 2 if it is a polyplat, where every cell is connected with every other cell either rook-wise or bishop-wise, so the cells are Moore connected. The seven most common still life forms of degree 2 are Beehive (53.6%), Loaf (16.1%), Boat (14.6%), Tub (3.3%), Pond (3.3%), Ship (7.1%), and Longboat (1.0%), which altogether represent 98.9% of all degree 2 still forms.
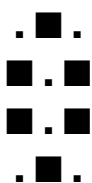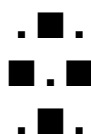
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.■.        .■.       .■■.      ■■.
■.■        ■.■       ■..■      ■.■
■.■        .■.       ■..■      .■■
.■.                  .■■.
```
Beehive (xs6_696)   Tub (xs4_252)   Pond (xs8_6996)   Ship (xs6_356)
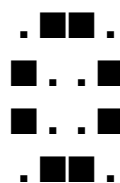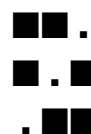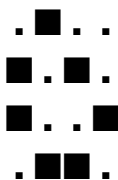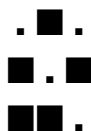
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.■..           .■.            .■..
■.■.           ■.■            ■.■.
■..■           ■■.            .■.■
.■■.                         ..■■
```
Loaf (xs7_2596)   Boat (xs5_253)   Longboat (xs7_25ac)
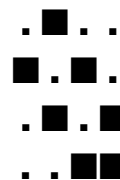
The four most common oscillating (periodic) life forms of degree 2 are Toad (76.23%), Beacon (23.71%), Clock (0.02%),

and Pentadecathlon (0.02%), which altogether represent 98.99% of all forms.

Note that oscillating forms have different configurations in the course of the period, so e.g. a period 4 form may have 4 different shapes with a different number of cells and different degree of connectedness. The figures below show the standard (minimal) apg code and the most connected stage, which may or may not be the same as the stage coded. As an example, the code (xp2_318c) codes the 6-cell stage of Beacon, while the image shows the 8-cell, connected stage.

Toad (xp2_7e)   Beacon (xp2_318c)   Clock (xp2_2a54)
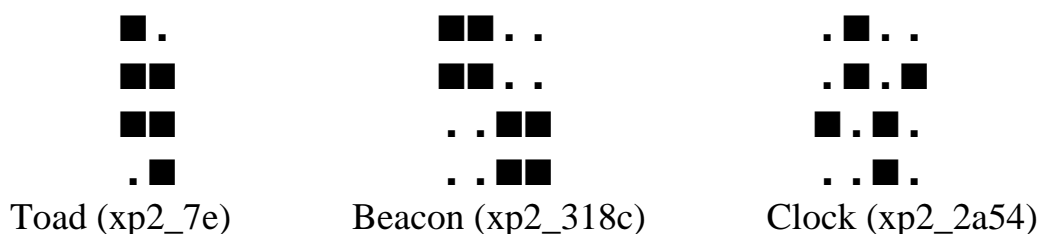
Some of the most common spaceships are also of degree 2: Glider (99.96% of spaceships in soups), Smallfish (0.03%) and Mediumfish (0.01%).

Glider (xq4_153)   Smallfish (xq4_6frc)   Mediumfish (xq2_27dee6)
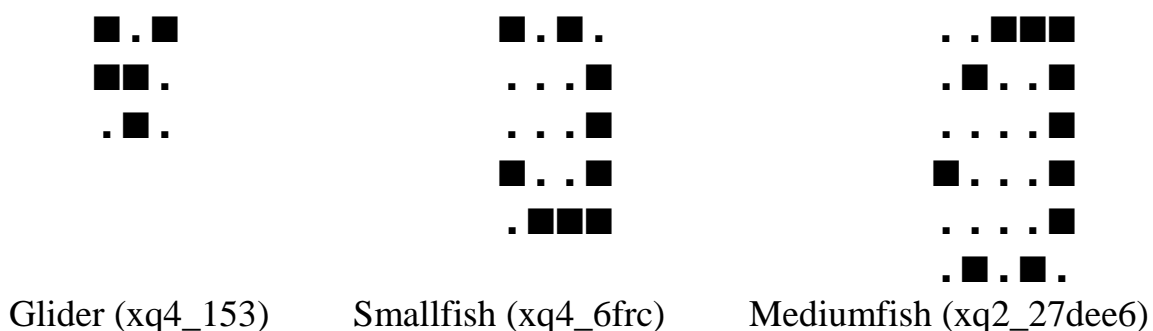
Degree 3 – (simple) unconnected forms

Various kinds of life forms can be of degree 3 including still and oscillating strict life forms, pseudo life forms and spaceships. The most common unconnected strict life forms of

degree 3 include Bitable (4.63%), Blockdock (3.20%) and Blocktable (2.85%).

```
■..■              ■..■              ■■..■■
■■■■              ■■■■              ■....■
....              ....              .■■■■.
■■■■              ..■■              ......
■..■              ..■■              .■■...
                                    .■■...
```
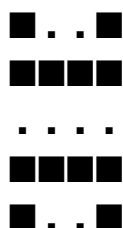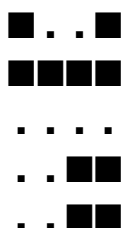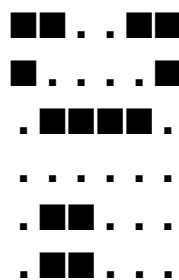
Bitable   Blocktable   Blockdock
(xs12_raar)   (xs10_32qr)   (xs14_j1u066z11)

The most common unconnected strict oscillating form, CP-pulsar is also of degree 3.

```
..■■.....■■..
...■■...■■...
■..■.■.■.■..■
■■■.■■.■■.■■■
.■.■.■.■.■.■.
..■■■...■■■..
.............
..■■■...■■■..
.■.■.■.■.■.■.
■■■.■■.■■.■■■
■..■.■.■.■..■
...■■...■■...
..■■.....■■..
```
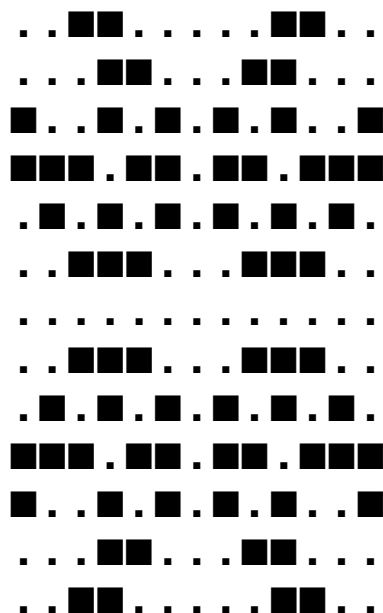
CP-pulsar (xp3_s0111s0s1110szo0555o0o5550oz1044410144401)

Pseudo life forms

Pseudo life forms are of degree 3. The most common ones are Biblock (70.6%), Bunbun (7.1%), Bunbun-B (3.6%) (together 10.7%), Nest (5.2%), Region (4.8%), Biarritz (1.2%). These altogether represent 92.5% of all pseudo forms in soups.

Biblock (xs8_rr) [o2]

Bunbun (xs12_6960696) [H2]

Bunbun-B (xs12_696z696) [H2]

Nest (xs10_660696) [Ho]

Biarritz (xs10_2l3z123) [B2]

Region (xs9_253033) [Bo]   Barley (xs13_6952z696) [HL]
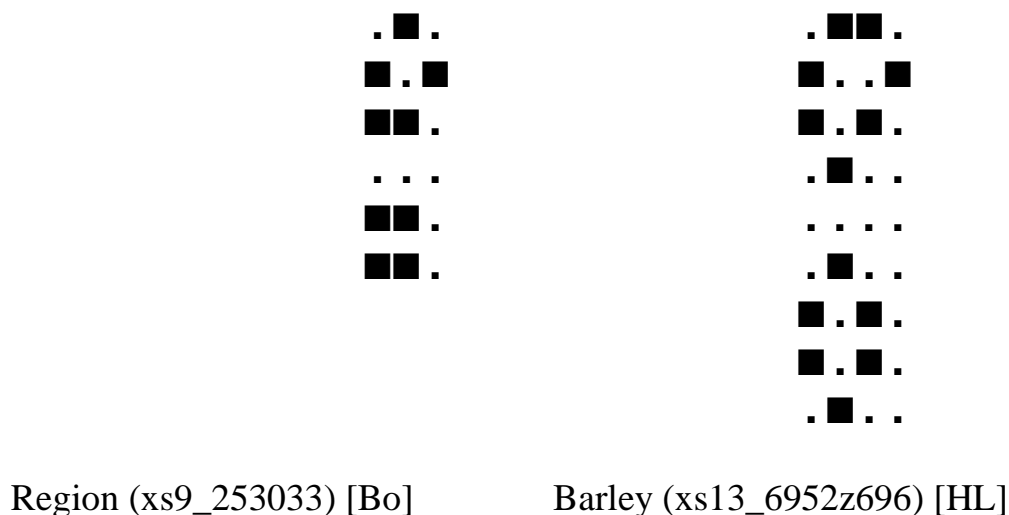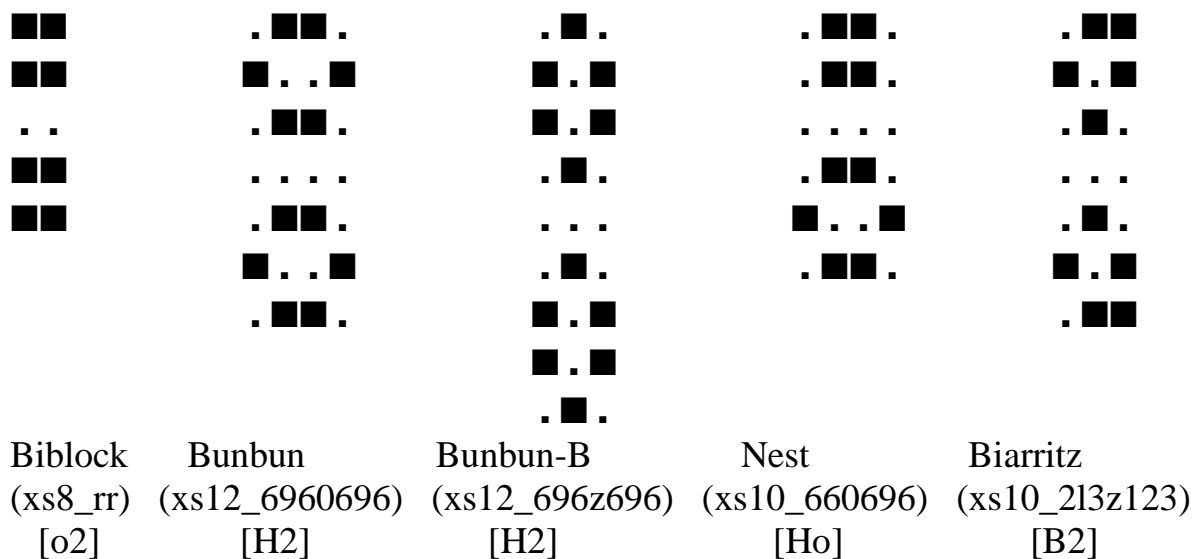
The six most common oscillating pseudo life forms are Pelican (46.26%), Record (26.07%), Quacks (10.15%), Professor (8.33%), Log (5.98%), and Target (1.82%), which altogether represent 98.61% of all such forms.

```
■        ■■.        ■■. .        .■■.
■        ■.■        ■■. .        ■. .■
■        .■.        . . . .      ■.■.
.        . . .      ■■. .        .■. .
■        . . .      ■. . .       . . . .
■        ■■■        . . .■       . . . .
■                   . .■■        ■■■.
```

Pelican   Quacks   Professor   Log
(xp2_nz3)   (xp2_352w7)   (xp2_rbzw23)   (xp2_6952w7)

```
      ■■■                    .■.
      . . .                  ■.■
      . . .                  .■.
      .■.                    . . .
      ■.■                    . . .
      ■.■                    ■■■
      .■.
```

Record (xp2_2552w7)   Target (xp2_252w7)
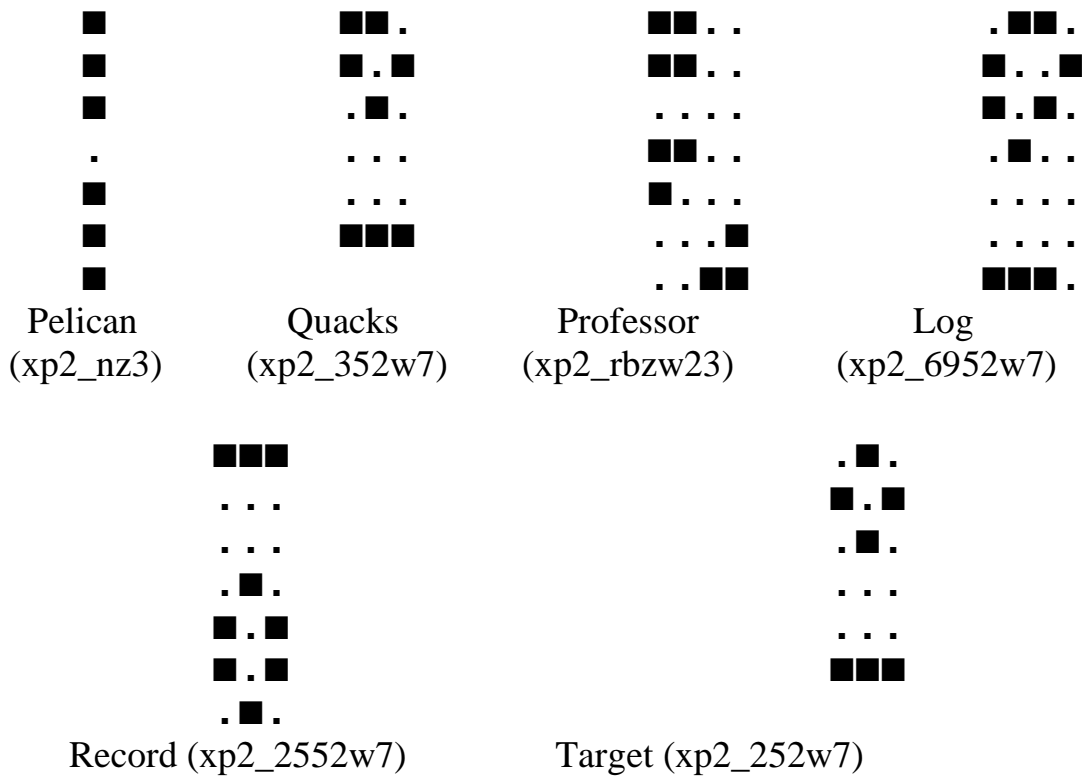
Degree 4 – unconnected forms

Various kinds of life forms can be of degree 4 including strict life forms, still and oscillating quasi life forms, oscillating constellations and spaceships. The most common unconnected strict life forms of degree 3 are Carrier (73.67%) and Brokensnake (0.36%).

```
      ■■.              . . . . .■■
      ■. .             ■.■■. .■
      . .■             ■■.■■. .
      .■■
```

Carrier (xs6_39c)   Brokensnake (xs10_0drz32)
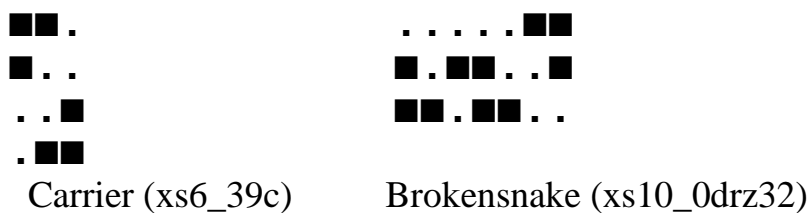
Quasi life forms

The most common still quasi life forms of degree 4 include Rapport (13.59%), Salt (13.11%), Salt-B (9.77%), and Raisin (6.54%).

```
■■...        .■...        ....■■
■■...        ■.■..        ....■■
.....        ■.■..        ......
...■■        .■...        .■■...
...■■        .....        ■..■..
             ...■■        .■■...
             ...■■
```

  Rapport   Salt   Salt-B
(xs8_330oo)   (xs10_25520oo)   (xs10_gg0696z11)
   [o2]   [Ho]   [Ho]

The most common oscillating quasi life forms of degree 4 include Traffic (49.33%), Page (17.78%), Triffic (15.85), Toil (2.61%), and Moan (2.17%), which altogether represent 87.74% of all forms.

```
..■■■..          ■■■..
.......          .....
■.....■          ....■
■.....■          ....■
■.....■          ....■
.......
..■■■..
```

  Traffic (xp2_s01110szw222)   Page (xp2_1110s)
           [i4]   [i2]

```
■■■..        ■■..        ■....
.....        ■■..        ■....
....■        ....        ■....
....■        ...■        ...■.
....■        ...■        ..■.■
.....        ...■        ..■.■
■■■..                    ...■.
```

Triffic (xp2_70ggg07)   Toil (xp2_33ws)   Moan (xp2_1118kk8)
　　　　[i3]　　　　　　　　　[io]　　　　　　　　　[Hi]
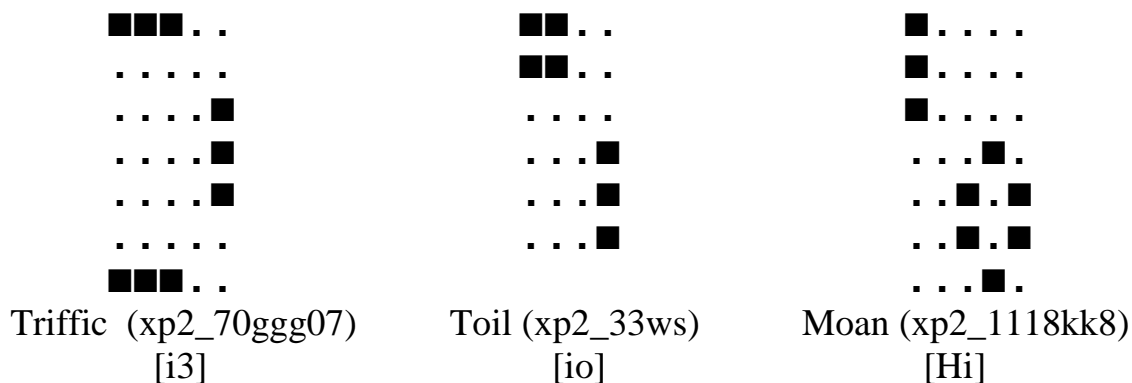
Degree 5

Degree 5 life forms include a few quasi live forms and many constellations. The only degree 5 quasi still form found in soups is Bakery (1.9%). Three oscillating quasi forms were found in soups: Reel-H (0.37%), Mishap-E (0.12%) and Boot-R (0.06%).

```
....■■....
...■..■...
...■.■....
.■■.■...■.
■..■...■.■
■.■...■..■
.■...■.■■.
....■.■...
...■..■...
....■■....
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Bakery
(xs28_g88m952g8gz1218kid221)
[Lb2]
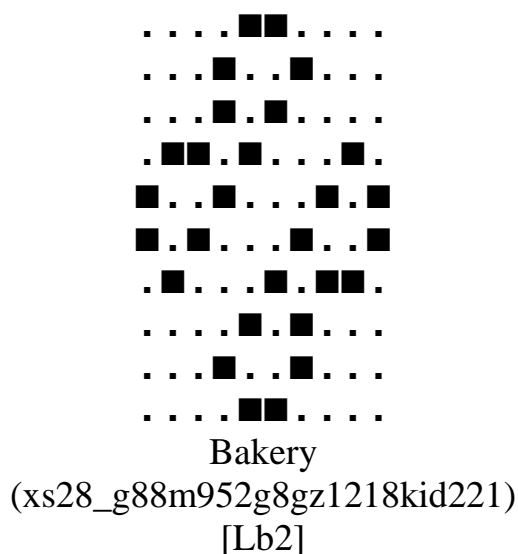
Constellations

The most common degree 5 still constellations are Honeyfarm (29.3%) and Savage (1.8%).

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. . . . . . ■ . . . . . .
. . . . . ■ . ■ . . . . .
. . . . . ■ . ■ . . . . .
. . . . . . ■ . . . . . .
. . . . . . . . . . . . .
. ■ ■ . . . . . . ■ ■ .
■ . . ■ . . . . ■ . . ■
. ■ ■ . . . . . . ■ ■ .
. . . . . . . . . . . . .
. . . . . . ■ . . . . . .
. . . . ■ . ■ . . . . .
. . . . . ■ . ■ . . . . .
. . . . . . ■ . . . . . .
```
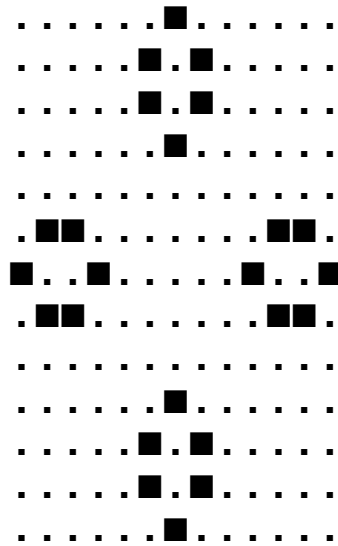
Honeyfarm (xs24_y1696z2552wgw2552zy1343) [H4]

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. ■ ■ . . . . . . .
■ . . ■ . . . . .
■ . ■ . . . . . .
. ■ . . . . ■ . .
. . . . . ■ . ■ .
. . . . . . ■ . . ■
. . . . . . . ■ ■ .
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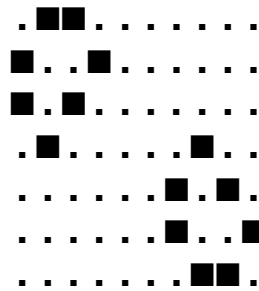
Savage (xs14_6952zx4aic) [L2]

The most common degree 5 oscillating constellations are Interchange (1.7%) and Jinxed (1.1%).

```
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■ ■ . . . ■ ■ . . . .
■ ■ . . . . . . . . .
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. . . . ■ ■ . . . . ■
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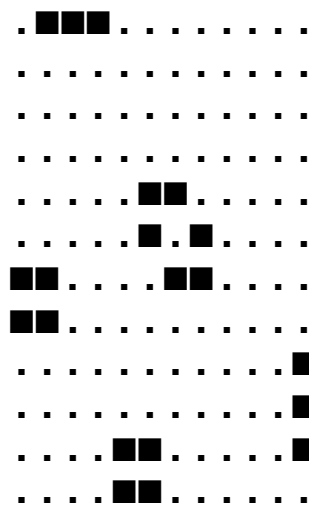
Jinxed (xp2_w7zccx356zy066y0111) [Si2o2]

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. . ▪▪▪ . . . . ▪▪▪ . .
. . . . . . . . . . . . . .
▪ . . . . . . . . . . . ▪
▪ . . . . . . . . . . . ▪
▪ . . . . . . . . . . . ▪
. . . . . . . . . . . . . .
. . ▪▪▪ . . . . ▪▪▪ . .
```

Interchan (xp2_ggg07y270gggzy0ey2e)   [i6]

Degree 6

All common degree 6 life forms are constellations. In fact, all common life forms above degree 5 are constellations. In particular, there are 7 spaceships of degree 2, 18 spaceships of degree 3, 35 spaceships of degree 4, 10 spaceships of degree 5, and none of higher degree. The most common still constellations of degree 6 are Hives (3.8%) and Vary (0.18%).

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▪ . . ▪ . . .
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. . . . . ▪ .
. . . . ▪ . ▪
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. . . . . . ▪ .
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. . . . ▪ . . ▪ . ▪ . . ▪ . . . .
. . . . . ▪▪ . . . ▪▪ . . . . .
▪▪ . . . . . . . . . . . . ▪▪
▪▪ . . . . . . . . . . . . ▪▪
. . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . .
▪▪ . . . . . . . . . . . . ▪▪
▪▪ . . . . . . . . . . . . ▪▪
. . . . . ▪▪ . . . ▪▪ . . . . .
. . . . ▪ . . ▪ . ▪ . . ▪ . . . .
. . . . . ▪▪ . . . ▪▪ . . . . .
```

Hives [H2]	Vary [H4o4]
(xs12_2552zy1696)	(xs40_0g033y0330gz3k3y43k3z343y4343zx33y033)

The most common oscillating constellations of degree 6 are Savas (0.48%) and Mine-N (0.18%).

```
. . ██ ██ . . . . . . . ██ .          ██ ██ . . . .
. ██ . . ██ . . . . . ██ . ██          ██ ██ . . . .
. ██ . . ██ . . . . . ██ ██          . . . . . .
. . ██ ██ . . . . . . . .          . . . . . .
. . . . . . . . . . . .          . . . . . .
. . . . . . . ██ ██ . .          . . . . . ██
. . . . . . . ██ ██ . .          . . . . . ██
. ██ ██ . . . . . . . .          . . . . . ██
██ . . ██ . . . . . . . .
. ██ ██ . . . . . . . .
. . . . . . . . . . . .
. . . . . . . . . . . .
. . . . . . . . . . . .
. . . . . . ██ ██ ██ . . . .
```

Savas [BHPio]   Mine-N [io]
(xp2_ciicx696zy1ggy2ez256w11)   (xp2_33zy17)

Degree 7 constellations

All common degree 7 life forms are constellations. The most common still constellations of degree 7 are Honeybit-B (1.43%) and Radar-W (0.61%).

```
██ ██ . . . . . .          . ██ .
██ ██ . . . . . .          ██ . ██
. . . . . . . .          . ██ .
. . . . . . . .          . . .
. . . . . . . .          . . .
. . . . . . . .          . . .
. . . . . ██ ██ .          . . .
. . . . ██ . . ██          ██ ██ .
. . . . ██ . . ██          ██ ██ .
. . . . . . ██ ██ .
```
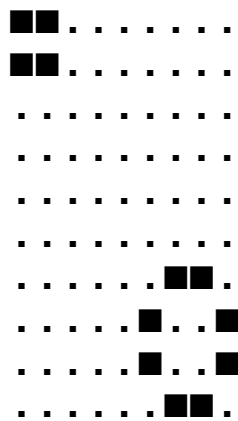
Honeybit-B [Po] (xs12_33zy1ciic)   Radar-W [To] (xs8_252zcc)
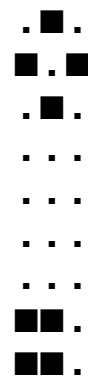
The most common oscillating constellations of degree 7 are Yacht-D (0.35%) and Primrose (0.18%).
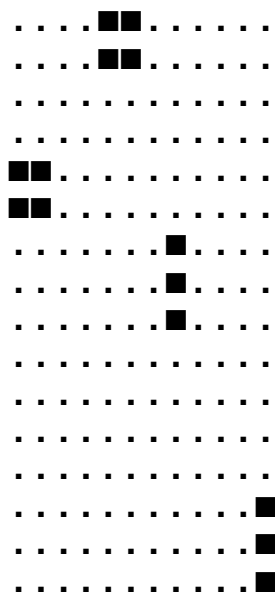
Yacht-D [i2o2]
(xp2_111y0gggzya66zy633)
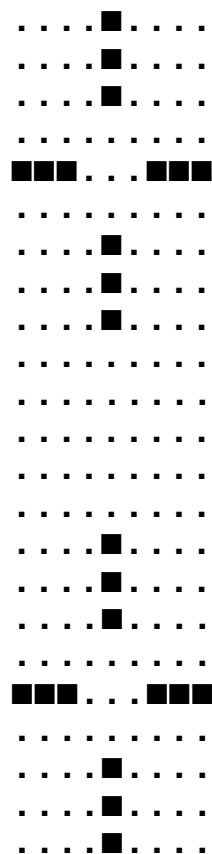
Primrose [i8]
(xp2_ggg070gggy1ggg070gggzy0ey9e)
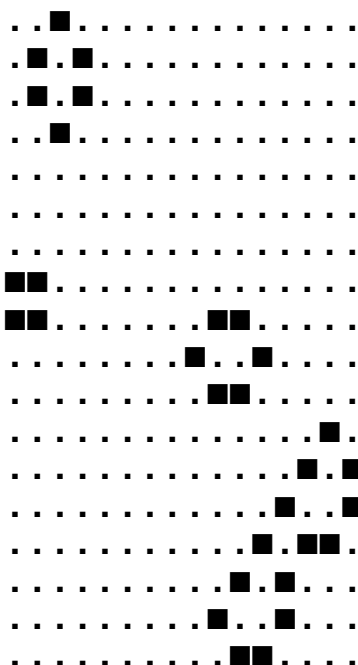
Riderisk [H2Lbo]
(xs30_0696zccy2g88gzy511g8kiczy52543)
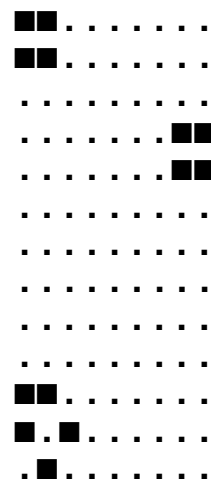
Scones-C [Bo2]
(xs13_33y1oozz352)

Degree 8 constellations

The most common still constellations of degree 8 are Riderisk (0.10%) and Scones-C (0.05%).

The most common oscillating constellations of degree 8 are Stalk (0.10%) and Celery-B (0.07%).
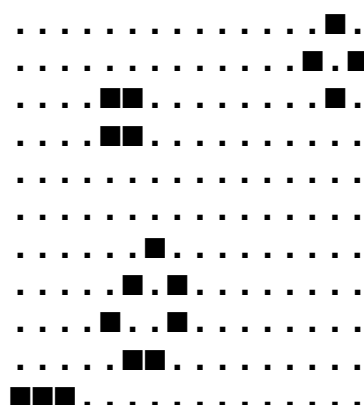
```
. . . . . . . . . . . .■.
. . . . . . . . . . . .■.■
. . . .■■. . . . . . . .■.
. . . .■■. . . . . . . . .
. . . . . . . . . . . . . .
. . . . . . . . . . . . . .
. . . . . .■. . . . . . . .
. . . . .■.■. . . . . . .
. . . .■.■. . . . . . . .
. . . .■■. . . . . . . .
■■■. . . . . . . . . . .
```
Stalk [LTio] (xp2_252y3cczy4cik8zy9111)
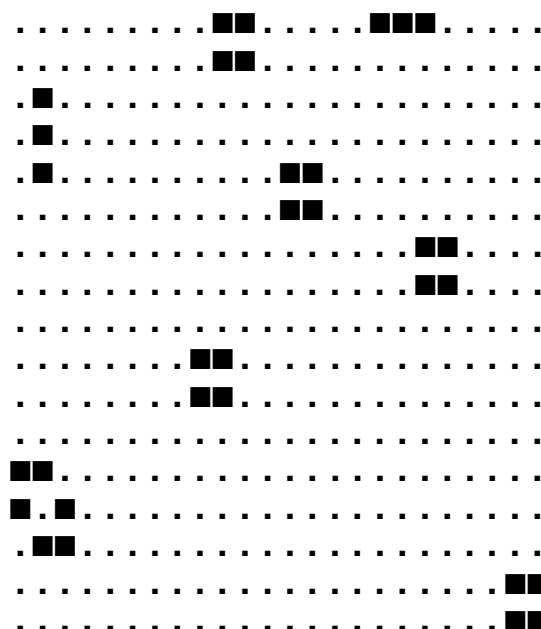
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. . . . . . . .■■. . . . .■■■. . . . .
. . . . . . . .■■. . . . . . . . . . .
.■. . . . . . . . . . . . . . . . . .
.■. . . . . . . . . . . . . . . . . .
.■. . . . . . . . .■■. . . . . . . .
. . . . . . . . . .■■. . . . . . . .
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■■. . . . . . . . . . . . . . . . . .
■.■. . . . . . . . . . . . . . . . .
.■■. . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . .■■
. . . . . . . . . . . . . . . . . .■■
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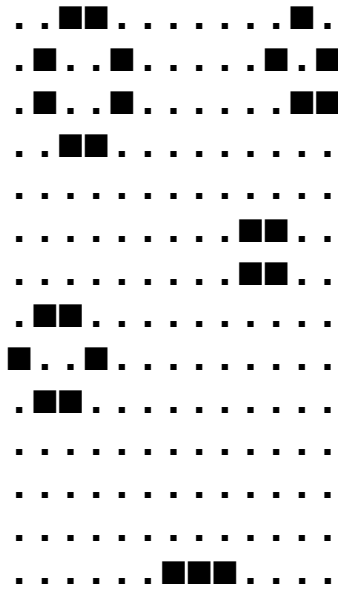Celery-B [Si2o5] (xp2_w222y3356zggy3ooz11wcczey1oozybcc)

Degree 9 constellations

The most common still constellations of degree 9 are Guiles-C (3.6%) and Earwig-E (1.13%).

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██.......        █..█.........
........         █.█.......██
██.......        .█.........██
██.......        ............
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......██        ..██........
......██        .█..█.......
                ..██.........
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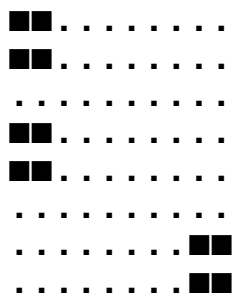
Guiles-C [o3] (xs12_rrzy466)   Earwig-E [HLo] (xs17_6952wciczzwcc)
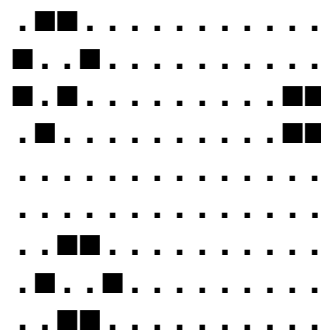
The most common oscillating constellations of degree 9 are Epelican-H (3.60%) and Guitar-E (0.90%).

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███....        ██.
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.....■         ...
               ███
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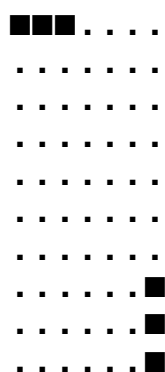
Epelican-H [i2] (xp2_111zy2s)   Guitar-E [Bi] (xp2_352y37)
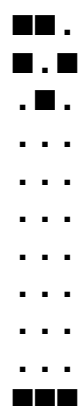
Degree 10 constellations

The most common still constellations of degree 10 are Mainly (0.30%) and Savage-C (0.26%).

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. . . . . . . . ■ . . ■
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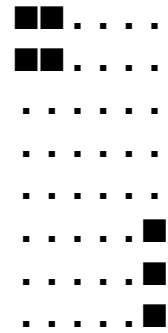
Savage-C   [L2] (xs14_4a96zzy66952)

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■ . ■ . . . . . . . . . . . . . . . . . . . . . . . ■■ .
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. . . . . . . . . . . . . . ■■ . . . . . . . ■ . ■ . . .
. . . . . . . . . . . . . . ■■ . . . . . . ■ . ■ . . .
. . . . . . . . . . . . . . . . . . . ■■ . . . .
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Mainly [B3H2Lo4]
(xs50_x33zycxggzx696y911zy5ccy1ca4x8koz8koycy44aa4zyb66y34a96)

The most common oscillating constellations of degree 10 are Fool-B (1.32%) and Rainripe (0.38%).

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. . . . . .■■. . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . .■. .■. . . . . . . . . . . . . . . . . . . . . . . . . . .
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■■. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
■■. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .■■
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .■■
. . . . . . . . . . . .■■. . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . .■. .■. . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . .■■. . . .■■■. . . . . . . . .■■. . . .
. . . . . . . . . . . . . . . . . . . . . . . . .■. .■. . . .
. . . . . . . . . . . . . .■. . . . .■. . . . . .■. .■. . .
. . . . . . . . . . . . . .■. . . . .■. . . . . . .■■. . . .
■. . . . .■. . . . . . . .■. . . . .■. . . . . . . . . . . .
■. . . . .■. . . . . . . . . . . . . . . . . . . . . . . . . .
■. . . . .■. . . . . . . . . . .■■■. . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. .■■■. . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
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. . . . . . . . . . . . . . .■. . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . .■. .■. . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . .■. . . . . . . . . . . . . . . . . .
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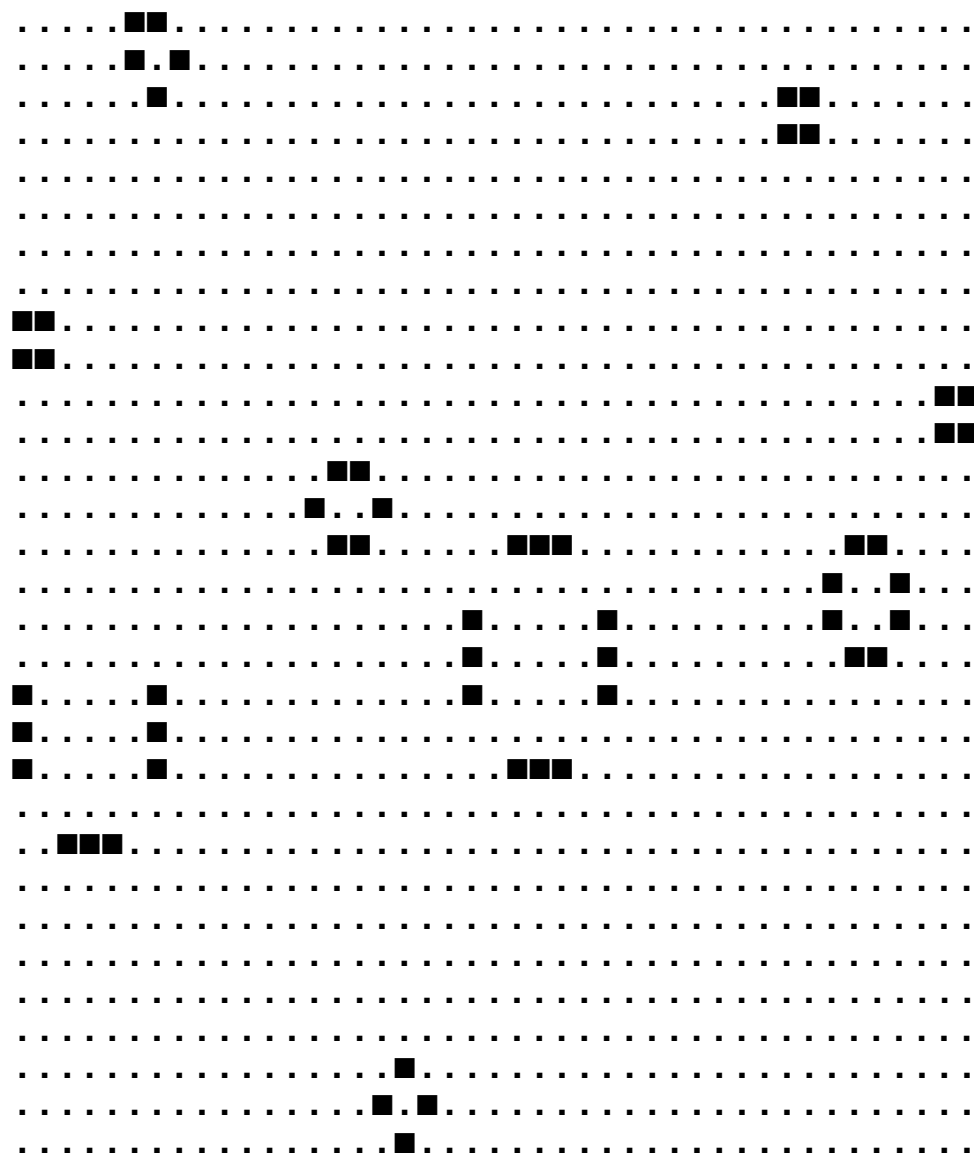
Rainripe   [BHPTi7o3]
(xp2_y433y41110sz352yb222zy8g8gzy8121y94a4zyas01110szyc222zwggzw1
1y6ciiczy666)

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...........■■■.
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Fool-B [i4o] (xp2_70gggy633zezy9111)

References

Jasko, T: Even size forms are more common in Conway's life. *Rer. Nat. Frag.* Nr. 480, 2022.

https://conwaylife.com/wiki/Still_life *[retrieved 16.Aug.22]*