BioChem

Emergent Simulated Chemistry

Discovered by @cactusjupiter
This is a 4-state cellular automaton, using the Moore neighborhood, with chaining behavior resembling chemical bonds and reactions.

Dictionary

Big Bangs - Uncontrolled creation of new mass and structures, often forming a large diamond shape after many generations. Most commonly formed by unchecked Reaction Cores.
Bilateral - In opposite directions, such as the symbol ↔ .

C Speed; C - Propagation at 1 cell per second in a direction, the maximum capable propagation rate of Moore Cellular Automata. Named after the Speed of Light constant in real life, C.

Front - Directional propagation made of a compound of structures. Fronts typically form on the edges of generations from noise.

Ship - A general moving Cellular Automata structure.
S[X] - State [X] in BioChem, S1 being State 1.

Specifications

How to Use

Install Golly at https://golly.sourceforge.io, if the most recent version doesn't work, this rule was made using Golly 5.0.
Create a file called "BioChem.rule", in the Golly program's Rules folder.
(***/golly-5.0-win-64bit/Rules on windows)
Copy the Rule File text below into the file using a text editor.
Open Golly, and click on BioChem.rule using the built in file manager.
Create, react, and play around!

Rule File

```
@RULE BioChem

In words:
```

S1 spawns from two S1 with a non S3 near an S0.

This drives the front of many engines.

S2 spawns from three S1 and an S3 near an S0.

S1 and S2 in crowded populations [(5+) and (6+) respectively] turn to S3 and S0 respectively.

S2 in medium populations (4-5) cycles back to S1

S3 near three S1, and one to two non-S0, cycles back to S2

Cycling back drives many chain reactions.

If none of the other stuff happened to this cell, S1 turns to S2, S2 turns to S3, and S3 dies.

made by cactusjupiter
4 state, Moore neighborhood cellular automaton with emergent stable mobile structures, sustained through chain reactions.

color schemes:
original:
1 100 150 200
2 50 110 150
3 40 80 110

classic contrast:
1 100 150 200
2 180 120 80
3 35 150 70
improved contrast:
1 40 130 225
2 180 120 80
3 75 140 30

cinnabar:
1 200 100 120
2 150 75 90
3 115 50 75

```
@TABLE

# Format: c,n,ne,e,se,s,sw,w,nw,c'

n_states:4
neighborhood: Moore
symmetries:permute
var a = {1,2,3}
var b = a
var c = a
var d = a
var e = a
var f = a
var na = {0,1,2,3}
var nb = na
var nc = na
var nd = na
var ne = na
var nf = na
var ng = na
var nh = na
var nba = {0,1,2}

# birth
0,1,1,nba,0,0,0,0,0,1
0,1,1,1,3,0,0,0,0,2

# fast death by overpop
1,a,b,c,d,e,na,nb,nc,3
2,a,b,c,d,e,f,na,nb,0

# them changes
2,a,b,c,d,na,0,0,0,1
3,1,1,1,a,na,0,0,0,2

# if nothing else, turn to next ticker
1,na,nb,nc,nd,ne,nf,ng,nh,2
2,na,nb,nc,nd,ne,nf,ng,nh,3
3,na,nb,nc,nd,ne,nf,ng,nh,0
```

```
# replace this down here with the color scheme of your choice
# current: improved contrast
@COLORS
1 40 130 225
2 180 120 80
3 75 140 30
```

The Fun Stuff

Various documented discoveries about the structures and interactions between them, as well as patterns and taxonomical classifications.

Reactivity and Reactions

General Behavior

Sustained reactions will almost always lead to movement. As a result, various ships, engines, and drives are the main structures of BioChem. S1 fronts cycle with short periods, reacting to extend the front forward at C speed. Reactions have strong directionality, and often require a catalyst or incoming reaction to change directions. Common structures with self replicating tendencies produce new energy for the system, and this energy can be harnessed for movement or creation. Unchecked self replication leads to uncontrollable growth, through big bangs. Polymer Chains are stable payloads, and are more likely to be modified than destroyed.

Periodic Producing Interactions

Reactions that repeatedly occur, producing new structures as a result. The most basic forms of PPIs are Cores, which periodically produce copies of themselves, and feed most larger PPIs.

General Taxonomy

Our knowledge of this is incomplete, some of this could be incorrect. For unknowns that are being assumed based on educated guesses, they are marked with [](?). These are likely to be true, but unproven. For things unexplained so far, they are marked with {}.

Cores

Simple, common, self replicating structures.

Reaction Core/ACS-2

The atom of reactions, responsible for starting and sustaining most of the Periodic Producing Interactions. Individually, it recreates itself in the opposite direction while moving, and these clones reactively collide with each other, causing explosive growth. It can form from drawing an orthogonal line of S1 of length 2, classifying it as an Atomic Chain Ship, ACS-2.

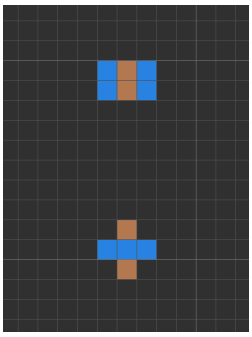

Figure 1

Sierpinski Core

Named for being the main component in Sierpinski's Triangle generators. Individually, it will replicate itself in a similar pattern to a 1D scan through a Sierpinski's Triangle. This is also the most simple ½ C speed structure, and the only known one.

Figure 1 shows a Reaction Core on the top, and a Sierpinski Core on the bottom.

Chain Ships

Chain Ships are a common type of moving structure that carry a polymer "chain" payload with them, having [only been found in orthogonal variants](?). They are composed of 3 main components, being an Engine, N length Polymers, and Chain Tails. Chain Ship collisions typically don't lead to annihilation, rather modifying the engine, or the polymers.

Engines

The engine creates the movement of chain ships, typically being wide, short, and found at the front of ships. They can be any length, but [chains can only form on the corners](?). All currently known engines only move at C speed. This is due to their aperiodic behavior, where C speed engines themselves transition directly from one state to the next, only changing through translation.

Polymer Engines

These are formed when two different engine fronts are connected by a reaction, occurring either at an engine's chain point, or within a chain. This can extend ships in both dimensions, forming more complex Chain Ships. This is also the main component principle of Polymer Ships.

Monomers

These are the key components of polymers, singular blocks that can be chained N amount of times. Ships perform reactions to make new monomers at the front, and the chain tails perform reactions to dispose of old monomers, creating movement. Some monomers can transition into others, forming compound chain structures.

Chain Tails

Chain tails perform reactions at the end of monomer chains. Typically, these destroy monomers at the same rate that they are created at, but there are rare Sub-C tail variants. These variants perform destructive reactions on the tails over a longer period, slowing it below C.

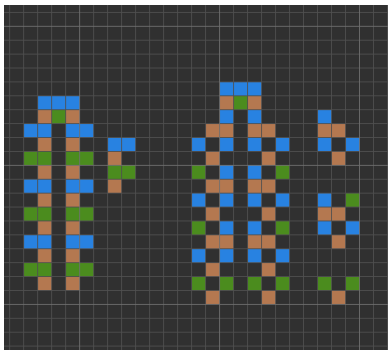

Figure 2

Here in Figure 2 are two chain ships, and their monomers next to them. Both use one monomer, but the reaction on the left sustains while remaining homogenous across its monomer chains, while the reaction on the right requires a tail at the end, and a transition monomer from the engine to the chain. Typically, these transition monomers and tails are variations on the main monomer.

Reaction Drives

Utilizing a simple unit, called a reaction core, new mass can be created. Reaction Drives are a common mobile structure, requiring a reaction core as input to continue moving, and typically outputting a reaction core behind it. Their main parts are the Reaction Head, Reaction Chain, and the Tidier. Reaction Drives are similar to chain ships, but have one, much more active chain, with easily interchangeable monomers.

Reactor

The Reaction Drive equivalent of a monomer. They take a reaction core in the front at one point in their cycle, and output a reaction core behind afterwards, then repeat. This reaction core catalyzes their cycle, being the cause for movement, and further reaction core production.

Reaction Head

This is where the primary input cores are produced. Most often, this structure is just a reaction core, as they are able to self replicate. From here, reaction cores go through the Reaction Chain.

Reaction Chain

Reaction Chains are an N-length chain of reactors. They take in reaction cores to sustain their reactors, passing reaction cores from one reactor to the next. In stable Reaction Drives, the chain ends in a Tidier.

Tidier

The tail to a Reaction Drive, typically taking in reaction cores and rendering them inert. Reaction Drives without these tails will output Reaction Cores behind them, creating explosive behavior.

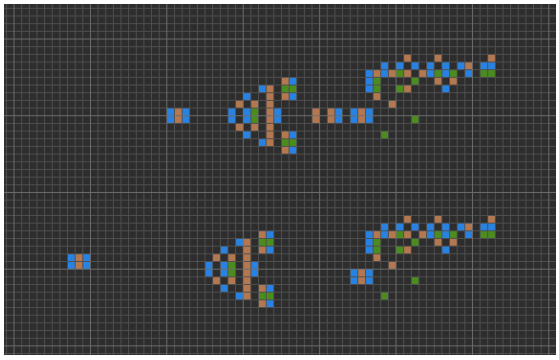

Figure 3

On the top half of Figure 3 is a small Reaction Drive, consisting of just one Reactor, with the Reaction Head on the left, and the Tidier on the right.
On the bottom half of Figure 3 is the exploded view, showing individually, from left to right, variants of the Reaction Head, the Reactor, and the Tidier.
This is just one example configuration, these systems are modular, most Reactors and Tidiers fit with each other when in phase.

Polymer Ships

These are made of continuous polymer engines, having a Synthesizer, a Polymer Engine Chain, and a Terminal. They most often form as large diagonal fronts, and can be told apart from other Ship Fronts by their interaction between engines. These diagonal fronts come from Engine Monomers being created to move perpendicular to the Synthesizer.

Synthesizer

Using a PPI, new engine monomers are created at a fast enough rate for the formation of one to affect the others, making codependent engine reactions. This forms Polymer Engine Chains, as their codependence creates stable and visible reactions between engines.

Engine Monomer

A singular repeating component of a Polymer Engine Chain, they are typically incapable of sustaining reactions outside of the PEC. It is also much more difficult to transition between Engine Monomers compared to other monomer types.

Terminal

The end to a Polymer Engine Chain, from which engine monomers are decomposed. This can resolve the chain, or form a PPI. The Terminal usually appears as a moving ship, reflecting or rendering inert the engine monomers without breaking the reaction. Sometimes the Terminal is

unclear, appearing more as a sudden end or dying of the reaction past a certain point, similar to Chain Ship tails.

Other Structures

Notable

Proven structures that have a characteristic unique to them.

Atomic Chain Ships

Atomic Chain Ships are the simplest* chain ships of a given width, formed by drawing an orthogonal line of S1 of that length. This straight line reacts perpendicular to itself, forming an engine which creates tails, creating 2 Chain Ships facing opposite each other. ACSs are typically period 2, with one exception.
Shown in Fig. 4 are the 3, 4, and 5 Atomic Chain Ships, top to bottom.
Can be referred to as ACS-x , where x is the engine width.
*Technically not the simplest ships, but referred to as the simplest for having elementary starting configurations to generate them.

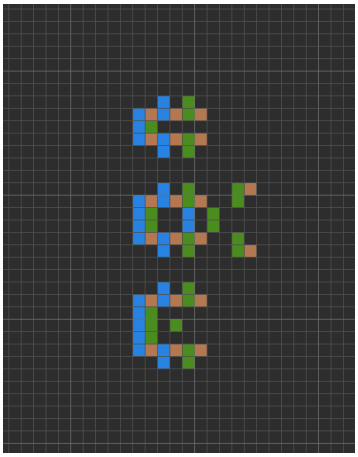

Figure 4

ACS-4

ACS-4 is a unique Atomic Chain Ship, it is the only true* ACS that is period 4. It produces temporary exhaust behind it, and forms braces between its tails.
*A true ACS is one that is self contained, not producing any lasting outward products or reactions. This distinguishes ACS-2 from the rest, as ACS-2, the Reaction Core, has large outward production.

Theoretical

Structures that are predicted to exist, but haven't been observed in practice.

Sierpinski Drive

A Reaction Drive-like structure, moving at Sub-C speeds, and utilizing Sierpinski Cores as opposed to Reaction Cores. The idea of this is backed up by the similarity of Reaction Cores and Sierpinski Cores in their bidirectional self replication, and the use of Reaction Cores in Reaction Drives.

Experimental Processes

Methods to create new structures and test for reactions between existing ones.

Collision Reactions

Polymer Chains are more likely to react than destroy when collided with, leading to the formation of new monomer transitions and tails. This is good for discovering ways to use PPI products, and is often used in conjunction with State Spaces.

State Space

By making a region that has many slight variations on a small setup, safely spaced out, many similar reactions can be tested at once. This is used to test ways to utilize products from known PPIs.

Grafting

Similar to the grafting of plants to create new varieties, new ship variants with certain desirable traits can be created by interchanging tails, monomers, and engines with each other. This often results in novel but hard to naturally generate ship designs.