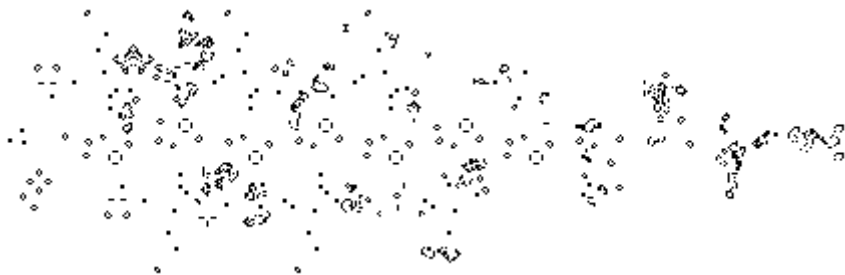# Patterns, Programs, and Links for Conway's Game of Life

Update (11-Feb-01)

This is the new location for the Game of Life page that I began in 1995 while at Johns Hopkins. If you have a link to the old URL, I'd appreciate it a lot if you could update it. I'm cleaning up some broken links for this release. Otherwise, it is roughly where I left it in 1998. The web has exploded with Life and general cellular automata resources since I began work on this page. An excellent starting point is the [Open Directory Life index](#), maintained by Mirek Wojtowicz.

My email address is callahanp@acm.org. Despite my inactivity on these pages, I still read this mail regularly and appreciate comments. I don't always remember to answer it, so send me a reminder if you don't hear from me in a couple of weeks.

--Paul

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Welcome

Welcome to my page of odds and ends about Conway's Game of Life. This page is an on-going work, which I hope to expand regularly. This page now contains descriptions of files I have made available for ftp, links to Life resources available elsewhere on the Internet, new results and patterns not archived elsewhere, and a browsable hypertext catalog of Alan Hensel's archive of Life patterns, including a hypertext version of his Life glossary. All the patterns except those in the glossary are Java-animated, so if you have a Java-compatible browser, such as Netscape 2.0, you may want to skip right to the [catalog](#) and take a look.

I should mention that while writing this page, I have generally assumed that the reader has at least *heard* of the Game of Life. But if you haven't, please don't let that stand in your way. [A brief explanation](#) can already be found elsewhere on the Web.

About the Picture

Depicted at the top of the page--if you don't recognize it already--is the classic puffer train. This is what it looks like after 800 *generations*, or applications of Game of Life transition rules. An exact duplicate of the initial pattern can be seen at the right end of the above picture, displaced 400 cell units from where it started, near the left end of the picture. The term "puffer train" was coined to describe just this pattern, because of the way it propagates forward while leaving a trail of "smoke" behind it. Since the time of its discovery, a great many patterns have been discovered with similar properties, and the term "puffer" has come to encompass the entire class. The Life pattern used to generate this picture appears in the browsable archive below. It is called puftrain.lif.

Browsable Pattern Catalog

My [illustrated catalog](#) of Life patterns provides the most convenient way yet to browse Alan Hensel's extensive archive of Life patterns. Linked to each pattern image is a page displaying comments, and you can examine and download the entire pattern file for viewing in a Life program on your machine. Better yet, if your browser supports Java, an applet will appear and start a Life animation automatically.

Alan's comments for the patterns are often terse (well, it's an awful lot of material to document) and use a rather specialized terminology. You may wish to refer to the [illustrated glossary](#) adapted from the one that Alan provided in his distribution A [text version](#) of the glossary is provided for those who are using a text-only browser, or who do not have a fast connection. For an even more comprehensive list of Life terms, see [Stephen Silver's lexicon](#).

Selected Topics

These links delve into the theory, operation, or design history of Life patterns and whole classes of patterns. The format is mixed and includes articles I've written for the page, as well as mail digests and contributed articles. In contrast to the pattern catalog, the emphasis here is on verbal explanation. Numerous patterns are nonetheless included as examples, and can be viewed in the applet or downloaded as ASCII files. Dates denote time of addition to this page.

- Mail digest on [Noam Elkies' period-24 glider gun](#): the densest non-interleaved (or "true") glider gun known (*20-Dec-97*).
- An [improved stable reflector](#) and related results by Stephen Silver (*20-Dec-97*).
- Bill Gosper's [totally aperiodic glider wave](#) (abridged mail digest) (*20-Dec-97*).
- Dieter Leithner's [period-57 Herschel oscillator](#) (*20-Dec-97*).
- Links to descriptions of [some alternative CA rules](#) (*20-Dec-97*).
- David Buckingham on [B-heptomino/Herschel oscillators](#) (*17-Apr-97*).
- David Bell's [c/5 spaceship](#) (*17-Apr-97*).
- David Bell's [c/3 puffers](#) (*17-Apr-97*).
- Mail digest on [gliderless spaceship guns](#) (*12-Apr-97*).
- [Brian Eno on Life](#) and its connection to generative music (*11-Mar-97*).
- Dean Hickerson's original description of his [sliding block memory](#) (*2-Dec-96*).
- Alan Hensel's discussion of [line puffers](#) (*2-Dec-96*).
- Life's [Holy Grails](#): stable reflectors and Herschel tracks (*27-Nov-96*).
- Dieter Leithner and Peter Rott's collection of [smallest known glider guns](#) (*12-Oct-96*).
- The smallest known [pseudo period-15 glider gun](#) (*16-Aug-96*).
- My [extensible delay line memory](#). (*5-Mar-96*).
- David Bell's [unit Life cell](#) (*1-Mar-96*).
- Tim Coe's [c/4 diagonal sparkers](#) (*1-Mar-96*).
- Tim Coe's [c/5 orthogonal spaceship](#) (*31-Jan-96*).
- New results on the [spacefiller](#) (*15-Nov-95*).
- Tim Coe's new [period-16 puffer engine](#) (*13-Nov-95*).

Resource List

Since about 1990, I have been using the Internet regularly to communicate with others interested in Conway's Game of Life. The introduction of the World Wide Web protocol and the current availability of browsers has greatly enhanced the Internet's potential for this purpose. The following list contains those Web resources best known to me, along with a brief description. The list is presented roughly in order, starting with what is readily accessible and fun for the novice, and progressing towards the more specialized and esoteric:

- A Web-page implementation of [John Conway's Game of Life](#). This one is, of necessity, slow and limited to a tiny cell universe, but it's an ingenious application of check boxes and it even runs in lynx.
- Some patterns and Life implementations available in my ftp directory.
  - Alan Hensel's zip-compressed archive of some of the world's most remarkable Life [patterns](#). To see these in action, you need a *fast* Life simulator that works with Hensel's format. Some useful documentation is included along with the patterns.
  - Alan Hensel's lightning-fast [MS/DOS implementation](#) of Life. Conveniently enough, this program works with his pattern format.
  - Compressed source for [Xlife 3.0](#), an X-windows implementation of Life. This accepts Hensel's format as well, but expects pattern files to have a ".life" suffix.
  - A semi-official upgrade [Xlife 3.5](#) at Achim Flammenkamp's web site. Enhancements are box cut-and-paste commands that I added but never released, and sub-pixel zooming by Achim for viewing extremely large patterns.
- Stephen Silver's comprehensive [Life Lexicon](#).
- X Motif source code I wrote for a 4-color version of life. The rules governing live and dead cells are the usual ones. However a cell can be one of four different colors, and these colors change according to a majority rule. This is distributed as a [gzipped Unix tape archive](#).
- My [Java still life generator](#), which uses an iterative approach to find patterns that are stable under life rules.
- David Bell's definitive treatise on [Spaceships in Conway's Game of Life](#), originally distributed as a Usenet article in flat ascii text, but since converted by Joerg Heitkoetter into an HTML document available through the Web.
- A Unix shell archive of David Bell's [search program](#) that finds low-period oscillators and spaceships. Many of the spaceships discussed in Bell's article were originally found with just such a search program. Note that this is the *5 Feb 94* release, which contains features not found in the older versions archived elsewhere.
- The Usenet newsgroup [comp.theory.cell-automata](#), which is devoted to the more general subject of cellular automata, but where Game of Life discussions are not unheard of.
- My December '94 Usenet article containing C source code for a [collision-enumeration program](#). Unfortunately, my program is not very user-friendly. It works with files and command-line arguments, and won't give you much of anything unless you know just what you are looking for. It has, however, resulted in some surprising finds. This is mainly of interest to the hardcore Life enthusiast with a lot of patience and a high tolerance for frustration.

Other Game of Life Pages

A great place to start looking for Game of Life information is the [Open Directory Life index](#). Here's my own random smattering of related links.

- Mark Niemiec's [massive compendium](#) of glider syntheses, still life enumerations, and other information for the true enthusiast.
- Robert Wainwright's [LIFEPAGE](#). This page collects information about Life patterns and results, as well as an index to LIFELINE, a newsletter edited by Wainwright from 1971 through 1973 in which many important results first appeared.
- [Achim's Game of Life Page](#). This page, maintained by Achim Flammenkamp, contains patterns, life results, and software, including Xlife 3.5, a newer release of Xlife containing some user-interface enhancements.
- Alan Hensel's [fast, powerful life applet](#) runs patterns in his collection and (unlike mine) also works interactively.
- H. Koenig's page of [Game of Life Information](#), which includes a listing of glider constructions.
- A [compilation of Life information](#) in Eric Weisstein's [Treasure Troves](#).

Additional Resources

Here is a sampling of related resources. I have not had the time to keep this list up to date ever since starting it in 1995. However, I am confident that starting here, almost everything can be found just a few links away.

Programs that can read patterns in Alan Hensel's archive

- [Life32](#) for Windows 95/98/NT by Johan Bontes. Alan Hensel calls this "by far, the best Life program for 32-bit Windows ... extremely fast, powerful, and easy to use." I've seen this demonstrated, and concur with Alan.
- W-Life, ported by Glen Summers, for PC's running MS-Windows 3.1. A decent port of Xlife to Microsoft Windows. Note that this is a port of Xlife 2.0, released in 1989. *I do not have an up to date link for this software*.
- [WinLife](#) by John Harper, for PC's running MS-Windows 3.1. Probably the best overall Windows Life program.
- [LifeLab](#) by Andrew Trevorrow, for Macs -- Mac Plus to Power Mac. Very powerful. Autodetects gliders and oscillators, has sophisticated editing, does automated searches for new patterns.

Artificial Life Resources

It is the source of much, occasionally rancorous, [debate](#) as to whether Conway's Game of Life and the field of artificial life have anything to do with one another, apart from the somewhat coincidental name correspondence. Both involve the study of complex, seemly unpredictable systems, so the connection is not entirely arbitrary. In any case, the following resources are in themselves interesting, and may help you find additional resources related to the Game of Life.

- [The Live Artificial Life Page](#) contains links to animations of artificial life systems on the Web.
- [Zooland](#) is an extensive index to artificial life resources on the Internet.
- [comp.ai.alife](#) is a Usenet group for the discussion of artificial life.
- David Griffeath's [Primordial Soup Kitchen](#) contains interesting patterns produced by all sorts of complex systems, including the Game of Life.

Contributors

The above links were contributed by Alan Hensel, Joerg Heitkoetter, and David Griffeath.

Off-line Resources

Not everything to do with the Game of Life can be found on the Internet, at least not yet. Alan Hensel has compiled a [bibliography](#) of books and articles on the Game of Life.

This page is maintained by Paul Callahan *(last update: 11-Feb-01)*.