John Conway's Game of Life Using Display Devices with Automatic Scrolling

Life has been presented before for specific video displays. Here are the routines necessary to run Life on any general display device.

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This is a much improved version of a previous article on the game of Life that was published in MICRO February 1979 (9:39). You can easily adapt this program for any 6502 computer by changing jump instructions between addresses 2096—20AF. You can use any display device, even a printer, if it will automatically roll the display upwards after the bottom line is printed.

The program is very fast. A carriage return occurs as soon as there are no more characters to be printed on a line. Moreover, two lines in the pond are printed as only one line on the display. Refer to the examples to see how this works.

Furthermore, you can change parameters in the program to adjust to the size of your display. Also, you can skip one or more generations between printings.

Martin Gardner published John Conway's game of Life in the October and November, 1970 issues of the *The Scientific American.* Our two examples were taken from his article.

We like to think of the game of Life as a computer simulation of a virus growing on a pond of DNA, using Conway's genetic rules, which are:

1. An empty cell having exactly 3 neighbors will give birth to a new cell.
2. A living cell having less than 2, or more than three neighbors will die.
3. All births and deaths occur at one time at the end of each generation; after all cells have been examined.

We kill all cells that touch the bank of the pond. This is necessary to prevent wrap-around. The pattern would be badly damaged if wrap-around growth were allowed to collide with the main organism. Because of our rather small pond, the display in our example 2 has already departed from the original pattern produced on an infinite pond.

The program occupies $298 bytes of RAM. The pond immediately follows the program. The following space is needed for the pond: 2*(CPL *(LIS + 1)).

After loading the program, start at address 2000 and depress "G". The computer will respond with "ENTER V,H?". This is your cue to start entering the verticle and horizontal coordinates for each living cell in the seed group that you want to start with. This is your way of planting the seed of the organism that you want to study.

These coordinates are displacements from an origin at the center of the screen. Positive directions are down and to the right. A coordinate may be any decimal digit less than "8", followed by a minus sign "-", if negative; or a space if positive. If you make a mistake, enter the letter "X" to erase the entry. (Any letter may be substituted for "X".)

ADDR	Parameter Name	Default Value	Description
2001	CPL	$20	Insert the number of characters per line in your display.
2005	LIS	$10	Insert the number of lines in your screen.
2009	GPB	$00	Insert the number of generations to be skipped between printings.

After you have entered coordinates for all of the living cells in the arrangement you want to start with, depress slash "/", and you are off and running.

The following two examples were given in Gardner's article:

***Example 1:* the famous traffic light. It is plotted on a pond 16 × 16.**

```
KIM
2000 A9 2001
2001 20 10.
2002 85 2005
2005 10 8.
2006 86 2000
2000 A9 C
```

```
0002
```



```
0003
```

```
0004
```

```
0005
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0006
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0007
```

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0008
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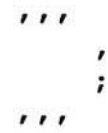
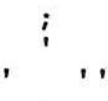
0009
```

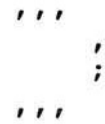
```
0010
```



```
0011
```



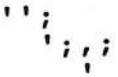
```
0012
```



***Example 2:* the R pentomino that was plotted to its death after 1103 generations at the Case Western Reserve University with a computer program by Gary Filipski and Brad Morgan, with the results sent in by Ranan B. Banerji. It has produced 6 gliders before death. Here we plot every tenth generation on our ASR 33 TTY at 110 BAUD.**

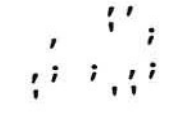
```
2000 A9 2009
2009 04 9.
200A 85 2000
2000 A9 C
```

```
0011
```

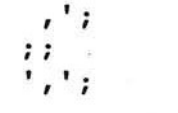


```
0021
```

```
0031
```



```
0041
```



```
0010: 2000           LIFE   ORG   $2000
0020: 2000           CPL    *     $0020   CHARACTERS PER LINE
0030: 2000           LIS    *     $0021   LINES IN SCREEN
0040: 2000           CENT   *     $0022   CENTER OF POND
0050: 2000           ADR    *     $0024   POINT TO PREV. LINE
0060: 2000           POINT  *     $0026   POINT TO CURRENT LINE
0070: 2000           BEFORE *     $0028   POINT TO LINE BEFORE POND
0080: 2000           POND   *     $002A   POINT TO START OF POND
0090: 2000           LAST   *     $002C     POINT TO LAST LINE IN POND
0100: 2000           BUFF   *     $002E   POINT TO BUFFER
0110: 2000           GC     *     $0030   GENERATION COUNT
0120: 2000           GBP    *     $0032   GENERATIONS BETWEEN PRINTS
0130: 2000           CNTG   *     $0033   COUNT OF GENERATIONS
0140: 2000           ACT    *     $0034   ACTIVITY
0150: 2000           OFFS   *     $0035   OFFSETS
0160: 2000           NN     *     $003D   NO. OF NEIGHBORS
0170: 2000           SAVY   *     $003E
0180: 2000 A9 20             LDAIM $20     SET 32
0190: 2002 85 20             STA   CPL     CHARS./LINE
0200: 2004 A2 10             LDXIM $10     SET 16
0210: 2006 86 21             STX   LIS     LINES IN SCREEN
0220: 2008 A9 00             LDAIM $00     SET ZERO
0230: 200A 85 32             STA   GBP     GENERATIONS BETWEEN PRINTS
0240: 200C A9 97             LDAIM END
0250: 200E 85 28             STA   BEFORE
0260: 2010 A9 22             LDAIM END     /256
0270: 2012 85 29             STA   BEFORE +01
0280: 2014 18                CLC
0290: 2015 A5 28             LDA   BEFORE
0300: 2017 65 20             ADC   CPL
0310: 2019 85 2A             STA   POND
0320: 201B 85 24             STA   ADR
0330: 201D A5 29             LDA   BEFORE +01
0340: 201F 69 00             ADCIM $00
0350: 2021 85 2B             STA   POND   +01
0360: 2023 85 25             STA   ADR    +01
0370:
0380:                  SET ADDRESS POINTERS
0390:
0400: 2025 20 B0 20          JSR   MULTA
0410: 2028 A5 20             LDA   CPL
0420: 202A 4A                LSRA
0430: 202B 18                CLC
0440: 202C 65 24             ADC   ADR
0450: 202E 85 22             STA   CENT
0460: 2030 A5 25             LDA   ADR    +01
0470: 2032 69 00             ADCIM $00
0480: 2034 85 23             STA   CENT   +01
0490: 2036 A6 21             LDX   LIS
0500: 2038 20 B0 20          JSR   MULTA
0510: 203B 18                CLC
0520: 203C A5 24             LDA   ADR
0530: 203E 85 2C             STA   LAST
0540: 2040 65 20             ADC   CPL
0550: 2042 85 2E             STA   BUFF
0560: 2044 A5 25             LDA   ADR    +01
LIFE
0570: 2046 85 2D             STA   LAST   +01
0580: 2048 69 00             ADCIM $00
0590: 204A 85 2F             STA   BUFF   +01
0600:
0610:                    SET OFFSETS
0620:
0630: 204C A9 00             LDAIM $00
0640: 204E 85 35             STA   OFFS
0650: 2050 18                CLC
0660: 2051 65 20             ADC   CPL
0670: 2053 85 36             STA   OFFS   +01
0680: 2055 65 20             ADC   CPL
0690: 2057 85 37             STA   OFFS   +02
0700: 2059 A9 01             LDAIM $01
0710: 205B 85 38             STA   OFFS   +03
0720: 205D 65 20             ADC   CPL
0730: 205F 65 20             ADC   CPL
0740: 2061 85 39             STA   OFFS   +04
0750: 2063 A9 02             LDAIM $02
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0760: 2065 85 3A            STA   OFFS   +05
0770: 2067 65 20            ADC   CPL
0780: 2069 85 3B            STA   OFFS   +06
0790: 206B 65 20            ADC   CPL
0800: 206D 85 3C            STA   OFFS   +07
0810:
0820:                  MAIN STRUCTURE
0830:
0840: 206F A0 00            LDYIM $00
0850: 2071 84 33            STY   CNTG
0860: 2073 84 30            STY   GC
0870: 2075 84 31            STY   GC     +01
0880: 2077 20 F2 20         JSR   CLEAR   POND
0890: 207A 20 34 21         JSR   PLANT   SEED
0900: 207D 20 D7 20  STAR   JSR   INCG     INC. GEN. COUNT
0910: 2080 20 9E 21         JSR   SHOALL   OF POND
0920: 2083 A0 00            LDYIM $00
0930: 2085 84 34            STY   ACT
0940: 2087 20 01 22         JSR   POST    BIRTHS AND DEATHS
0950: 208A 20 5A 22         JSR   UPDATE   POND
0960: 208D A5 34            LDA   ACT     IF ACTIVITY IS
0970: 208F D0 EC            BNE   STAR    ZERO
0980: 2091 00               BRK
0990: 2092 00               BRK              HALT
1000: 2093 20 80 20         JSR   STAR   +03  SHOW POND
1010:
1020:                  LINKAGE TO KIM ROUTINES
1030:
1040: 2096 4C 3B 1E  PRTBYT JMP   $1E3B
1050: 2099 84 3E     GETCH  STY   SAVY
1060: 209B 20 5A 1E         JSR   $1E5A
1070: 209E A4 3E            LDY   SAVY
1080: 20A0 60               RTS
1090: 20A1 A9 0D     CRLF   LDAIM $0D
1100: 20A3 20 A8 20         JSR   OUTCH
1110: 20A6 A9 0A            LDAIM $0A
1120: 20A8 84 3E     OUTCH  STY   SAVY
LIFE
1130: 20AA 20 A0 1E         JSR   $1EA0
1140: 20AD A4 3E            LDY   SAVY
1150: 20AF 60               RTS
1160:
1170:                  ADD CPL TO ADR  (X) TIMES
1180:
1190: 20B0 CA        MULTA  DEX
1200: 20B1 30 FC            BMI   MULTA  -01
1210: 20B3 18               CLC
1220: 20B4 A5 24            LDA   ADR
1230: 20B6 65 20            ADC   CPL
1240: 20B8 85 24            STA   ADR
1250: 20BA A9 00            LDAIM $00
1260: 20BC 65 25            ADC   ADR    +01
1270: 20BE 85 25            STA   ADR    +01
1280: 20C0 4C B0 20         JMP   MULTA
1290:
1300:                  SUBTRACT  CPL (X) TIMES FROM ADR
1310:
1320: 20C3 60               RTS
1330: 20C4 CA        SUBA   DEX
1340: 20C5 30 FC            BMI   SUBA   -01
1350: 20C7 38               SEC
1360: 20C8 A5 24            LDA   ADR
1370: 20CA E5 20            SBC   CPL
1380: 20CC 85 24            STA   ADR
1390: 20CE A5 25            LDA   ADR    +01
1400: 20D0 E9 00            SBCIM $00
1410: 20D2 85 25            STA   ADR    +01
1420: 20D4 4C C4 20         JMP   SUBA
1430:
1440:                  INCREMENT AND DISPLAY GEN. COUNT
1450:
1460: 20D7 20 A1 20  INCG   JSR   CRLF
1470: 20DA 18               CLC
1480: 20DB F8               SED
1490: 20DC A9 01            LDAIM $01
1500: 20DE 65 30            ADC   GC
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```
1510: 20E0 85 30           STA   GC
1520: 20E2 A5 31           LDA   GC     +01
1530: 20E4 69 00           ADCIM $00
1540: 20E6 85 31           STA   GC     +01
1550: 20E8 D8              CLD
1560: 20E9 20 96 20        JSR   PRTBYT
1570: 20EC A5 30           LDA   GC
1580: 20EE 20 96 20        JSR   PRTBYT
1590: 20F1 60              RTS
1600:
1610:                 CLEAR POND
1620:
1630: 20F2 20 8B 22  CLEAR JSR   MOVE
1640: 20F5 A5 21           LDA   LIS
1650: 20F7 0A              ASLA
1660: 20F8 85 3D           STA   NN
1670: 20FA A4 20           LDY   CPL
1690: 20FC 88        CLR   DEY
LIFE
1700: 20FD 30 06           BMI   CLR    +09
1701: 20FF A9 00           LDAIM $00
1710: 2101 91 24           STAIY ADR
1720: 2103 F0 F7           BEQ   CLR
1730: 2105 A2 01           LDXIM $01
1740: 2107 20 B0 20        JSR   MULTA
1750: 210A C6 3D           DEC   NN
1760: 210C 10 EC           BPL   CLR    -02
1770: 210E 60              RTS
1780:
1790: 210F 20 A1 20  ENTRVH JSR   CRLF
1800: 2112 A2 0B           LDXIM $0B
1810: 2114 BD 1E 21        LDAAX ENT
1820: 2117 20 A8 20        JSR   OUTCH
1830: 211A CA              DEX
1840: 211B 10 F7           BPL   ENTRVH +05
1850: 211D 60              RTS
1860: 211E 20        ENT   =     '
1870: 211F 3F              =     '?
1880: 2120 20              =     '
1890: 2121 48              =     'H
1900: 2122 2C              =     ',
1910: 2123 56              =     'V
1920: 2124 20              =     '
1930: 2125 52              =     'R
1940: 2126 45              =     'E
1950: 2127 54              =     'T
1960: 2128 4E              =     'N
1970: 2129 45              =     'E
1980: 212A 20 99 20  GET   JSR   GETCH
1990: 212D C9 38           CMPIM '8
2000: 212F 30 02           BMI   DONE
2010: 2131 A9 00           LDAIM $00
2020: 2133 60        DONE  RTS
2030:
2040:                  PLANT SEED
2050:
2060: 2134 20 0F 21  PLANT JSR   ENTRVH
2070: 2137 20 2A 21        JSR   GET
2080: 213A F0 F8           BEQ   PLANT
2090: 213C C9 30           CMPIM '0
2100: 213E 30 F3           BMI   DONE
2110: 2140 29 07           ANDIM $07
2120: 2142 AA              TAX
2130: 2143 A5 22           LDA   CENT
2140: 2145 85 24           STA   ADR
2150: 2147 A5 23           LDA   CENT   +01
2160: 2149 85 25           STA   ADR    +01
2170: 214B 20 2A 21        JSR   GET
2180: 214E F0 E4           BEQ   PLANT
2190: 2150 C9 2D           CMPIM '-
2200: 2152 F0 05           BEQ   MINUS
2210: 2154 20 B0 20        JSR   MULTA
2220: 2157 30 03           BMI   HOR
2230: 2159 20 C4 20  MINUS JSR   SUBA
2240: 215C A2 02     HOR   LDXIM $02
LIFE
2250: 215E 20 14 21        JSR   ENTRVH +05
2260: 2161 20 2A 21        JSR   GET
2270: 2164 C9 30           CMPIM '0
2280: 2166 30 CC           BMI   PLANT
2290: 2168 29 07           ANDIM $07
2300: 216A 85 3D           STA   NN
2310: 216C 20 2A 21        JSR   GET
2320: 216F F0 C3           BEQ   PLANT
2330: 2171 C9 2D           CMPIM '-
2340: 2173 F0 16           BEQ   MIN
2350: 2175 18              CLC
2360: 2176 A5 24           LDA   ADR
2370: 2178 65 3D           ADC   NN
2380: 217A 85 24           STA   ADR
2390: 217C A5 25           LDA   ADR    +01
2400: 217E 69 00           ADCIM $00
2410: 2180 85 25           STA   ADR    +01
2420: 2182 A9 01           LDAIM $01
2421: 2184 A0 00           LDYIM $00
2430: 2186 91 24           STAIY ADR
2440: 2188 4C 34 21        JMP   PLANT
2450: 218B 38        MIN   SEC
2460: 218C A5 24           LDA   ADR
2470: 218E E5 3D           SBC   NN
2480: 2190 85 24           STA   ADR
2490: 2192 A5 25           LDA   ADR    +01
2500: 2194 E9 00           SBCIM $00
2510: 2196 4C 82 21        JMP   MIN    -09
2520:
2530:                  SHOW ALL OF POND
2540:
2550: 2199 A5 32           LDA   GBP
2560: 219B 85 33           STA   CNTG
2570: 219D 60              RTS
2580: 219E C6 33     SHOALL DEC  CNTG
2590: 21A0 10 FB           BPL   SHOALL -01
2600: 21A2 20 8B 22        JSR   MOVE
2610: 21A5 A5 21           LDA   LIS
2620: 21A7 85 3D           STA   NN
2630: 21A9 A2 01     SHO   LDXIM $01
2640: 21AB 20 B0 20        JSR   MULTA
2650: 21AE C6 3D           DEC   NN
2660: 21B0 F0 E7           BEQ   SHOALL -05
2680: 21B2 A4 20           LDY   CPL
2690: 21B4 B1 24           LDAIY ADR
2700: 21B6 D0 04           BNE   SHOA
2710: 21B8 A9 20           LDAIM $20
2720: 21BA 10 02           BPL   SHOA   +02
2730: 21BC A9 27     SHOA  LDAIM $27
2740: 21BE 91 2E           STAIY BUFF
2750: 21C0 88              DEY
2760: 21C1 D0 F1           BNE   SHOA   -08
2770: 21C3 A2 01           LDXIM $01
2780: 21C5 20 B0 20        JSR   MULTA
2790: 21C8 A4 20           LDY   CPL
2800: 21CA B1 24     SHOW  LDAIY ADR
LIFE
2810: 21CC F0 0E           BEQ   SHOWB  +02
2820: 21CE B1 2E           LDAIY BUFF
2830: 21D0 C9 20           CMPIM $20
2840: 21D2 F0 04           BEQ   SHOWB  -02
2850: 21D4 A9 3B           LDAIM ';
2860: 21D6 10 02           BPL   SHOWB
2870: 21D8 A9 2C           LDAIM ',
2880: 21DA 91 2E     SHOWB STAIY BUFF
2890: 21DC 88              DEY
2900: 21DD D0 EB           BNE   SHOW
2910: 21DF A4 20           LDY   CPL
2920: 21E1 B1 2E           LDAIY BUFF
2930: 21E3 C9 20           CMPIM $20
2940: 21E5 D0 03           BNE   SHOWA
2950: 21E7 88              DEY
2960: 21E8 D0 F7           BNE   SHOWB  +07
2970: 21EA C8        SHOWA INY
2980: 21EB A9 0D           LDAIM $0D
2990: 21ED 91 2E           STAIY BUFF
```

```
3000: 21EF A0 00           LDYIM $00
3010: 21F1 20 A1 20        JSR   CRLF
3020: 21F4 C8        SHOP  INY
3030: 21F5 B1 2E           LDAIY BUFF
3040: 21F7 C9 0D           CMPIM $0D
3050: 21F9 F0 AE           BEQ   SHO
3060: 21FB 20 A8 20        JSR   OUTCH
3070: 21FE 4C F4 21        JMP   SHOP
3080:
3090:                 POST BIRTHS AND DEATHS
3100:
3110: 2201 20 8B 22  POST  JSR   MOVE
3120: 2204 20 79 22        JSR   INCP
3130: 2207 A9 00           LDAIM $00
3140: 2209 85 3D           STA   NN
3150: 220B A2 07           LDXIM $07
3160: 220D B5 35     NBR   LDAZX OFFS
3170: 220F A8              TAY
3180: 2210 B1 24           LDAIY ADR
3190: 2212 F0 04           BEQ   NB
3200: 2214 30 02           BMI   NB
3210: 2216 E6 3D           INC   NN
3220: 2218 CA        NB    DEX
3230: 2219 10 F2           BPL   NBR
3240: 221B A0 00           LDYIM $00
3250: 221D A5 3D           LDA   NN
3260: 221F C9 02           CMPIM $02
3270: 2221 30 20           BMI   DEATH
3280: 2223 C9 03           CMPIM $03
3290: 2225 F0 24           BEQ   BIRTH
3300: 2227 10 1A           BPL   DEATH
3310: 2229 20 73 22  POSTA JSR   INCA
3320: 222C D0 D9           BNE   POST   +06
3330: 222E 20 8B 22  EDGE  JSR   MOVE
3340: 2231 A5 21           LDA   LIS
3350: 2233 0A              ASLA
3360: 2234 85 3D           STA   NN
LIFE

3370: 2236 98              TYA
3380: 2237 91 24           STAIY ADR
3390: 2239 A2 01           LDXIM $01
3400: 223B 20 B0 20        JSR   MULTA
3410: 223E C6 3D           DEC   NN
3420: 2240 10 F4           BPL   EDGE   +08
3430: 2242 60              RTS
3440: 2243 B1 26     DEATH LDAIY POINT
3450: 2245 F0 E2           BEQ   POSTA
3460: 2247 A9 02           LDAIM $02
3470: 2249 10 06           BPL   BIRTH  +06
3480: 224B B1 26     BIRTH LDAIY POINT
3490: 224D D0 DA           BNE   POSTA
3500: 224F A9 FF           LDAIM $FF
3510: 2251 91 26           STAIY POINT
3520: 2253 E6 34           INC   ACT
3530: 2255 F0 FC           BEQ   BIRTH  +08
3540: 2257 4C 29 22        JMP   POSTA
3550:
3560:                 UPDATE POND
3570:
3580: 225A 20 8B 22  UPDATE JSR   MOVE
3590: 225D B1 26           LDAIY POINT
3600: 225F 30 08           BMI   ADULT
3610: 2261 C9 02           CMPIM $02
3620: 2263 30 08           BMI   ADULT  +04
3630: 2265 A9 00     BURY  LDAIM $00
3640: 2267 F0 02           BEQ   ADULT  +02
3650: 2269 A9 01     ADULT LDAIM $01
3660: 226B 91 26           STAIY POINT
3670: 226D 20 79 22        JSR   INCP
3680: 2270 D0 EB           BNE   UPDATE +03
3690: 2272 60              RTS
3700: 2273 E6 24     INCA  INC   ADR
3710: 2275 D0 02           BNE   INCP
3720: 2277 E6 25           INC   ADR    +01
3730: 2279 E6 26     INCP  INC   POINT
3740: 227B D0 02           BNE   INCP   +06
3750: 227D E6 27           INC   POINT  +01
3760: 227F A5 27           LDA   POINT  +01
3770: 2281 C5 2D           CMP   LAST   +01
3780: 2283 30 05           BMI   MOVE   -01
3790: 2285 38              SEC
3800: 2286 A5 26           LDA   POINT
3810: 2288 E5 2C           SBC   LAST
3820: 228A 60              RTS
3830: 228B A2 03     MOVE  LDXIM $03
3840: 228D B5 28           LDAZX BEFORE
3850: 228F 95 24           STAZX ADR
3860: 2291 CA              DEX
3870: 2292 10 F9           BPL   MOVE   +02
3880: 2294 A0 00           LDYIM $00
3890: 2296 60              RTS
3900: 2297 00        END   =     $00
3910: 2298 00              =     $00

SYMBOL TABLE 3300 3450
ACT    0034  ADR    0024  ADULT  2269  BEFORE 0028
BIRTH  224B  BUFF   002E  BURY   2265  CENT   0022
CLEAR  20F2  CLR    20FC  CNTG   0033  CPL    0020
CRLF   20A1  DEATH  2243  DONE   2133  EDGE   222E
END    2297  ENTRVH 210F  ENT    211E  GBP    0032
GC     0030  GETCH  2099  GET    212A  HOR    215C
INCA   2273  INCG   20D7  INCP   2279  LAST   002C
LIFE   2000  LIS    0021  MINUS  2159  MIN    218B
MOVE   228B  MULTA  20B0  NB     2218  NBR    220D
NN     003D  OFFS   0035  OUTCH  20A8  PLANT  2134
POINT  0026  POND   002A  POST   2201  POSTA  2229
PRTBYT 2096  SAVY   003E  SHOA   21BC  SHOALL 219E
SHOP   21F4  SHOW   21CA  SHOWA  21EA  SHOWB  21DA
SHO    21A9  STAR   207D  SUBA   20C4  UPDATE 225A
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