LIFE

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The game of LIFE was first introduced in the October 1970 issue
of Scientific American magazine. The Dazzler-Life program is
a truly spectacular full-color interpretation of the interesting
and varied game of LIFE. This program was written by Ed Hall.

Memory Requirements

The first 4K bytes of memory space is used for the Life program and
for the Dazzler picture. Life is provided as a paper tape listing
that loads from zero and runs from zero.

Loading the Paper Tape

The following procedure can be used to load the LIFE paper tape into
your computer. The procedure assumes that your paper tape reader
is interfaced using the MITS REV 0 I/O convention.

1) Using your front panel switches, deposit this paper tape load
   software into your computer beginning at memory location 010 000:

Location	Data
010 000	041
	000
	000
	333
	000
	346
	040
	312
	003
	010
	333
	001
	167
	043
	303
	003
	010

2) Examine location 010 000 (the data lights should read 041).
3) Run. Stop. (This clears the input buffer).
4) Examine location 010 000.
5) Align the first byte of data on the paper tape over the read sensors
   on your teletype or other paper tape reader.
6) Run.
7) Start the paper tape reader.
8) After the tape is read depress Stop.
9) To start Life: Reset. Run.

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Operation

After the paper tape is loaded into your computer, an initial colony of cells can be drawn on your TV screen using keyboard controls. Control A is used to deposit a cell of life on the screen. Controls N, O, I, and H step the cursor up, down, right, and left respectively. Control B can be used to earase the screen. Once the initial colony is complete, Control D is used to start the evolution of the cells. During the colorful evolution of the cells the letter F on your keyboard can be used to freeze the picture. Hit the letter G to go and the letter S to stop.

The details of the game of Life are described succinctly in this excerpt from the February 1976 issue of Popular Electronics :

THE GAME OF LIFE

One of the most fascinating uses of the Dazzler is in playing what is known as "The Game of Life." (See *Scientific American,* October 1970, p 120; February 1971, p 112; April 1971, p 116.) The game is started by entering the program shown below. (A paper tape of the program is available for $15 from Cromemco, 1 First St., Los Altos, CA 94022.) Then a colony of cells is entered to appear on the TV screen on a 64 x 64 grid.

Each cell in the colony has eight possible neighbors, as shown at right. The evolution of the colony proceeds according to a fixed set of rules invented by John Conway at the University of Cambridge. Every cell with two or three neighbors will survive to the next generation. Every cell with four or more neighbors dies from over-population. Every cell with one neighbor or no neighbors dies from isolation. Every cell with exactly three neighbors is a birth cell—a new cell is born here in the subsequent generation.

In the Dazzler version of The Game of Life, blue represents life; birth generates a green cell; and death is shown in red. There are many surprises to be found in the game. Some colonies survive and prosper; others reach a stable state—neither grow-ing nor lessening. Other colonies fade from existence. Some colonies, known as "gliders" sail across the screen and can be devoured by other colonies in the process.

The full-color illustrations on the first page of this article are actual photos of a TV screen several generations into a Life program.

The initial colony of cells is drawn on the TV screen using ASCII keyboard inputs as controls. Control A deposits a cell of life on the screen. Controls N, O, *I*, and *H* step the cursor up, down, right, and left, respectively. Once the initial colony is complete, Control D is initiated to start the game.
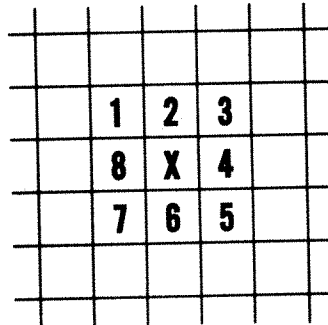
Each cell has 8 possible neighbors.

On the following pages is the assembler listing for Dazzler-Life.

```
0000                      0000 * LIFE ....VERSION 2.0
0000                      0001 * WRITTEN BY ED HALL
0000                      0002 * ASSEMBLED BY GORDEN FRENCH
0000                      0003 * AND RDM
0000 C3 03 00            0005    JMP START
0003 31 00 08            0010 START LXI SP,STACK
0006 CD 6A 01            0020    CALL INIT
0009 CD 8F 01            0030 MAN20 CALL SETUP
000C CD 2D 00            0040 MAN30 CALL GEN
000F DB 01               0050 FRZE IN 1
0011 FE 46               0052    CPI 'F'
0013 CA 0F 00            0054    JZ FRZE
0016 CD 42 00            0060    CALL CHANGE
0019 DB 01               0070 STP IN 1
001B FE 53               0072    CPI 'S'
001D CA 09 00            0074    JZ MAN20
0020 DB FF               0080 MAN40 IN 255
0022 17                  0090    RAL
0023 DA 20 00            0100    JC MAN40
0026 17                  0110    RAL
0027 DA 09 00            0120    JC MAN20
002A C3 0C 00            0130    JMP MAN30
002D 01 00 00            0260 GEN LXI B,0
0030 CD 84 00            0270 GEN20 CALL UPDATE
0033 3E 40               0280    MVI A,64
0035 0C                  0290    INR C
0036 B9                  0300    CMP C
0037 C2 30 00            0310    JNZ GEN20
003A 0E 00               0312    MVI C,0
003C 04                  0314    INR B
003D B8                  0316    CMP B
003E C2 30 00            0318    JNZ GEN20
0041 C9                  0320    RET
0042 01 00 00            0330 CHANGE LXI B,0
0045 CD E9 00            0340 CHN15 CALL GTCOL
0048 FE 09               0350    CPI RED
004A C2 55 00            0360    JNZ CHN20
004D 3E 00               0370    MVI A,0
004F CD FA 00            0380    CALL PTCOL
0052 C3 5F 00            0390    JMP CHN30
0055 FE 0A               0400 CHN20 CPI GREEN
0057 C2 5F 00            0410    JNZ CHN30
005A 3E 0C               0420    MVI A,BLUE
005C CD FA 00            0430    CALL PTCOL
005F 3E 40               0440 CHN30 MVI A,64
0061 0C                  0450    INR C
0062 B9                  0460    CMP C
0063 C2 45 00            0470    JNZ CHN15
0066 0E 00               0480    MVI C,0
0068 04                  0490    INR B
0069 B8                  0500    CMP B
006A C2 45 00            0510    JNZ CHN15
006D C9                  0520    RET
006E 21 00 08            0530 CDISP LXI H,DISPLY
0071 11 00 F8            0540    LXI D,-2048
```

```
0074 06 00          0550 CLEAR MVI B,0
0076 3E 00          0560 FILL MVI A,0
0078 BA             0570 FLL12 CMP D
0079 C2 7E 00       0580    JNZ FLL20
007C BB             0590    CMP E
007D C8             0600    RZ
007E 70             0610 FLL20 MOV M,B
007F 13             0620    INX D
0080 23             0630    INX H
0081 C3 78 00       0640    JMP FLL12
0084 C5             0650 UPDATE PUSH B
0085 3E 00          0660    MVI A,0
0087 B9             0670    CMP C
0088 C2 9C 00       0680    JNZ UPD10
008B 0D             0690    DCR C
008C CD CC 00       0700    CALL UPROW
008F 32 2A 02       0710    STA ROWA
0092 C1             0720    POP B
0093 C5             0730    PUSH B
0094 CD CC 00       0740    CALL UPROW
0097 32 2C 02       0750    STA ROWB
009A C1             0760    POP B
009B C5             0770    PUSH B
009C 0C             0780 UPD10 INR C
009D CD CC 00       0790    CALL UPROW
00A0 21 2C 02       0800    LXI H,ROWB
00A3 46             0810    MOV B,M
00A4 77             0820    MOV M,A
00A5 80             0830    ADD B
00A6 2B             0840    DCX H
00A7 4E             0850    MOV C,M
00A8 70             0860    MOV M,B
00A9 81             0870    ADD C
00AA 57             0880    MOV D,A
00AB C1             0890    POP B
00AC C8             0900    RZ
00AD D5             0910    PUSH D
00AE CD E9 00       0920    CALL GTCOL
00B1 D1             0930    POP D
00B2 FE 00          0940    CPI 0
00B4 CA C3 00       0950    JZ UPD20
00B7 7A             0960    MOV A,D
00B8 FE 03          0970    CPI 3
00BA C8             0980    RZ
00BB FE 04          0990    CPI 4
00BD C8             1000    RZ
00BE 3E 09          1010    MVI A,RED
00C0 C3 FA 00       1020    JMP PTCOL
00C3 7A             1030 UPD20 MOV A,D
00C4 FE 03          1040    CPI 3
00C6 C0             1050    RNZ
00C7 3E 0A          1060    MVI A,GREEN
00C9 C3 FA 00       1070    JMP PTCOL
00CC 05             1080 UPROW DCR B
00CD 16 00          1085    MVI D,0 FIX
00CF CD DC 00       1090    CALL UPONE
00D2 04             1100    INR B
```

```
00D3 CD DC 00        1110    CALL UPONE
00D6 04              1120    INR B
00D7 CD DC 00        1130    CALL UPONE
00DA 7A              1140    MOV A, D
00DB C9              1150    RET
00DC D5              1160 UPONE PUSH D
00DD CD E9 00        1170    CALL GTCOL
00E0 D1              1180    POP D
00E1 FE 00           1190    CPI 0
00E3 C8              1200    RZ
00E4 FE 0A           1202    CPI 10 FIX
00E6 C8              1204    RZ FIX
00E7 14              1210    INR D
00E8 C9              1220    RET
00E9 CD 16 01        1230 GTCOL CALL FNDCOL
00EC 7E              1240    MOV A, M
00ED DA F3 00        1250    JC GT20
00F0 E6 OF           1260    ANI 15
00F2 C9              1270    RET
00F3 E6 FO           1280 GT20 ANI 240
00F5 07              1290    RLC
00F6 07              1300    RLC
00F7 07              1310    RLC
00F8 07              1320    RLC
00F9 C9              1330    RET
00FA E6 OF           1340 PTCOL ANI 15
00FC F5              1350    DB OF5H
00FD CD 16 01        1360    CALL FNDCOL
0100 D1              1370    POP D
0101 DA 0A 01        1380    JC PTC20
0104 7E              1390    MOV A, M
0105 E6 FO           1400    ANI 240
0107 82              1410    ADD D
0108 77              1420    MOV M, A
0109 C9              1430    RET
010A 7A              1440 PTC20 MOV A, D
010B 07              1450    RLC
010C 07              1460    RLC
010D 07              1470    RLC
010E 07              1480    RLC
010F 57              1490    MOV D, A
0110 7E              1500    MOV A, M
0111 E6 OF           1510    ANI 15
0113 82              1520    ADD D
0114 77              1530    MOV M, A
0115 C9              1540    RET
0116 21 00 08        1550 FNDCOL LXI H, DISPLY
0119 78              1560    MOV A, B
011A E6 20           1570    ANI 32
011C CA 23 01        1580    JZ FND20
011F 11 00 02        1590    LXI D, 512
0122 19              1600    DAD D
0123 79              1610 FND20 MOV A, C
0124 E6 20           1620    ANI 32
0126 CA 2D 01        1630    JZ FND30
0129 11 00 04        1640    LXI D, 1024
012C 19              1650    DAD D
```

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012D 79          1660 FND30 MOV A, C
012E E6 1F       1670    ANI 31
0130 07          1680    RLC
0131 07          1690    RLC
0132 07          1700    RLC
0133 17          1710    RAL
0134 5F          1720    MOV E, A
0135 3E 00       1730    MVI A, 0
0137 17          1740    RAL
0138 57          1750    MOV D, A
0139 19          1760    DAD D
013A 78          1770    MOV A, B
013B 1F          1780    RAR
013C F5          1790    DB OF5H
013D E6 OF       1800    ANI 15
013F 5F          1810    MOV E, A
0140 16 00       1820    MVI D, 0
0142 19          1830    DAD D
0143 F1          1840    DB OF1H
0144 C9          1850    RET
0145 DB 00       1860 CHECK IN 0
0147 E6 20       1870    ANI DAV
0149 C0          1880    RNZ
014A 0C          1890    INR C
014B C2 45 01    1900    JNZ CHECK
014E 04          1910    INR B
014F C2 45 01    1920    JNZ CHECK
0152 C9          1930    RET
0153 DB 00       1940 TTYONE IN 0
0155 E6 02       1950    ANI TBE
0157 CA 53 01    1960    JZ TTYONE
015A 78          1970    MOV A, B
015B D3 01       1980    OUT 1
015D C9          1990    RET
015E 46          2000 TTYOUT MOV B, M
015F 3E 00       2010    MVI A, 0
0161 B8          2020    CMP B
0162 C8          2030    RZ
0163 CD 53 01    2040    CALL TTYONE
0166 23          2050    INX H
0167 C3 5E 01    2060    JMP TTYOUT
016A CD 6E 00    2070 INIT CALL CDISP
016D 3E 84       2080    MVI A, 132
016F D3 OE       2090    OUT 14
0171 3E B0       2100    MVI A, 176
0173 D3 OF       2110    OUT 15
0175 21 2E 02    2120    LXI H, IDENT
0178 CD 5E 01    2130    CALL TTYOUT
017B CD 45 01    2140 INT20 CALL CHECK
017E             2150 * INSERT JZ INT 20 HERE FOR INST
017E DB 01       2160    IN 1
0180 47          2170    MOV B, A
0181 CD 53 01    2180    CALL TTYONE
0184 E6 7F       2190    ANI 127
0186 FE 59       2200    CPI 89
0188 C9          2210    RET INSERT RZ HERE FOR INST
0189 21 48 02    2220    LXI H, INST
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018C CD 5E 01        2230   CALL TTYOUT
018F 21 4A 02        2240 SETUP LXI H, ENTER
0192 CD 5E 01        2250   CALL TTYOUT
0195 CD 6E 00        2260   CALL CDISP FIX
0198 01 00 00        2265   LXI B, 0
019B CD F9 01        2270 STP20 CALL GTCHR
019E 21 C0 01        2280   LXI H, TAB
01A1 E6 7F           2288   ANI 7FH FIX
01A3 57              2290   MOV D, A
01A4 97              2300 STP30 SUB A
01A5 BE              2310   CMP M
01A6 CA 9B 01        2320   JZ STP20
01A9 7A              2330   MOV A, D
01AA BE              2340   CMP M
01AB CA B4 01        2350   JZ STP40
01AE 23              2360   INX H
01AF 23              2370   INX H
01B0 23              2380   INX H
01B1 C3 A4 01        2390   JMP STP30
01B4 23              2400 STP40 INX H
01B5 5E              2410   MOV E, M
01B6 23              2420   INX H
01B7 56              2430   MOV D, M
01B8 EB              2440   XCHG
01B9 CD BF 01        2450   CALL INDEX
01BC C3 9B 01        2460   JMP STP20
01BF E9              2470 INDEX PCHL
01C0 01              2480 TAB DB 1
01C1 E9 01           2490   DW ON
01C3 02              2500   DB 2
01C4 F0 01           2510   DW OFF
01C6 04              2520   DB 4
01C7 DF 01           2530   DW THRU
01C9 08              2540   DB 8
01CA F7 01           2550   DW BACK
01CC 09              2560   DB 9
01CD EE 01           2570   DW FWD
01CF 0F              2580   DB 15
01D0 E7 01           2590   DW DOWN
01D2 0B              2600   DB 11
01D3 E1 01           2610   DW HOME
01D5 0D              2620   DB 13
01D6 E5 01           2630   DW RETURN
01D8 0E              2640   DB 14
01D9 F5 01           2650   DW UP
01DB 00              2660   DB 0
01DC 00              2670   DB 0
01DD 00              2680   DB 0
01DE 00              2690   DB 0
01DF C1              2700 THRU POP B
01E0 C9              2710   RET
01E1 01 00 00        2720 HOME LXI B, 0
01E4 C9              2730   RET
01E5 06 00           2740 RETURN MVI B, 0
01E7 0C              2750 DOWN INR C
01E8 C9              2760   RET
01E9 3E 0F           2770 ON MVI A, 15
```

```
01EB CD FA 00          2780 BOTH CALL PTCOL
01EE 04                2790 FWD INR B
01EF C9                2800  RET
01F0 3E 00             2810 OFF MVI A, 0
 1F2 C3 EB 01          2820  JMP BOTH
01F5 0D                2830 UP DCR C
01F6 C9                2840  RET
01F7 05                2850 BACK DCR B
01F8 C9                2860  RET
01F9 CD E9 00          2870 GTCHR CALL GTCOL
01FC F5                2880  DB 0F5H
01FD C5                2890 GTC20 PUSH B
01FE 3E 0C             2900  MVI A, 12
0200 CD FA 00          2910  CALL PTCOL
0203 01 00 00          2920  LXI B, DELAY
0206 CD 45 01          2930  CALL CHECK
0209 C2 26 02          294  JNZ GTC40
020C C1                2950  POP B
020D C5                2952  PUSH B
020E 3E 00             2954  MVI A, 0
0210 CD FA 00          2956  CALL PTCOL
0213 01 00 00          2958  LXI B, DELAY
0216 CD 45 01          2959  CALL CHECK
0219 C1                2962  POP B
021A CA FD 01          2964  JZ GTC20
021D F1                2968 GTC30 POP 6
021E CD FA 00          2970  CALL PTCOL
0221 DB 01             2980  IN 1
0223 D3 01             2990  OUT 1
 225 C9                3000  RET
 226 C1                3010 GTC40 POP B
0227 C3 1D 02          3020  JMP GTC30
022A                   3030 RED EQU 9
022A                   3040 STACK EQU 800H
022A                   3045 DISPLY EQU 800H
022A                   3050 TIME EQU 0D800H
022A                   3060 GREEN EQU 10
022A                   3070 BLUE EQU 12
022A 00 00             3080 ROWA DW 0
022C 00 00             3090 ROWB DW 0
022E                   3100 DAV EQU 32
022E                   3110 TBE EQU 2
022E                   3120 SP EQU 6
022E                   3140 DELAY EQU 0
022E 4C 49             3150 IDENT DW 'IL'
0230 46 45             3151  DW 'EF'
0232 2E 2E             3152  DW '..'
0234 2E 2E             3153  DW '..'
0236 56 45             3154  DW 'EV'
0238 52 53             3155  DW 'SR'
023A 49 4F             3156  DW 'OI'
023C 4E 20             3157  DW ' N'
023E 32 2E             3158  DW '.2'
0240 30 20             3159  DW ' 0'
0242 0D 0A             3160  DW 0A0DH
 244 0A 0A             3161  DW 0A0AH
0246 00 00             3162  DW 0
```

```
0248 00 00          3200 INST   DW O
024A 45 4E          3400 ENTER  DW 'NE'
024C 54 45          3401    DW 'ET'
024E 52 20          3402    DW ' R'
0250 44 41          3404    DW 'AD'
0252 54 41          3406    DW 'AT'
0254 OD 0A          3407    DW OAODH
0256 00 00          3408    DW O
```

LIFE ..... OCTAL LISTING


```
           303 003 000 061 000 010 315 152 001 315 217 001 315 055 000 333
           001 376 106 312 017 000 315 102 000 333 001 376 123 312 011 000
           333 377 027 332 040 000 027 332 011 000 303 014 000 001 000 000
           315 204 000 076 100 014 271 302 060 000 016 000 004 270 302 060
           000 311 001 000 000 315 351 000 376 011 302 125 000 076 000 315
           372 000 303 137 000 376 012 302 137 000 076 014 315 372 000 076
           100 014 271 302 105 000 016 000 004 270 302 105 000 311 041 000
Low 160    010 021 000 370 006 000 076 000 272 302 176 000 273 310 160 023
200        043 303 170 000 305 076 000 271 302 234 000 015 315 314 000 062
           052 002 301 305 315 314 000 062 053 002 301 305 014 315 314 000
240        041 053 002 106 167 200 053 116 160 201 127 301 310 325 315 351
           000 321 376 000 312 303 000 172 376 003 310 376 004 310 076 011
300        303 372 000 172 376 003 300 076 012 303 372 000 005 026 000 315
           334 000 004 315 334 000 004 315 334 000 172 311 325 315 351 000
340        321 376 000 310 376 012 310 024 311 315 026 001 176 332 363 000
           346 017 311 346 360 007 007 007 007 311 346 017 365 315 026 001
           321 332 012 001 176 346 360 202 167 311 172 007 007 007 007 127
420        176 346 017 202 167 311 041 000 010 170 346 040 312 043 001 021
           000 002 031 171 346 040 312 055 001 021 000 004 031 171 346 037
           007 007 007 027 137 076 000 027 127 031 170 037 365 346 017 137
           026 000 031 361 311 333 000 346 040 300 014 302 105 001 004 302
           105 001 311 333 000 346 002 312 123 001 170 323 001 311 106 076
540        000 270 310 315 123 001 043 303 136 001 315 156 000 076 204 323
           016 076 260 323 017 041 056 002 315 136 001 315 105 001 311 001
           107 315 123 001 346 177 376 131 311 041 110 002 315 136 001 041
           112 002 315 136 001 315 156 000 001 000 000 315 371 001 041 300
           001 346 177 127 227 276 312 233 001 172 276 312 264 001 043 043
           043 303 244 001 043 136 043 126 353 315 277 001 303 233 001 351
           001 351 001 002 360 001 004 337 001 010 367 001 011 356 001 017
           347 001 013 341 001 015 345 001 016 365 001 000 000 000 000 301
740        311 001 000 000 311 006 000 014 311 076 017 315 372 000 004 311
           076 000 303 353 001 015 311 005 311 315 351 000 365 305 076 014
           315 372 000 001 000 000 315 105 001 302 046 002 301 305 076 000
           315 372 000 001 000 000 315 105 001 301 312 375 001 361 315 372
           000 333 001 323 001 311 301 303 035 002 000 000 001 000 114 111
           106 105 056 056 056 056 126 105 122 123 111 117 116 040 062 056
           060 040 015 012 012 012 000 000 000 000 105 116 124 105 122 040
           104 101 124 101 015 012 000 000 000 000 000 000 000 000 000 000
           000 000 000 000 000 000 000 000 007 007 007 007 007 007 007 007
```