

Program Description I

Program Title

LIFE

Contributor's Name

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Program Description, Equations, Variables

LIFE IS PLAYED ON THE 10x10 ARRAY AS SHOWN TO THE RIGHT. A ZERO IS USED TO INDICATE AN EMPTY CELL AND A ONE IS USED TO INDICATE AN OCCUPIED CELL. A NEIGHBOR IS AN OCCUPIED CELL IN ANY OF THE EIGHT ADJACENT CELLS TO THAT OF THE CELL IN QUESTION. THE GENETIC LAWS ARE:

ROW 9

ROW 8

ROW 7

ROW 6

ROW 5

ROW 4

ROW 3

ROW 2

ROW 1

ROW 0

10 COLUMNS

0.0	0	0	0	0	0	0	0	0	0
0.0	0	0	0	0	0	0	0	0	0
0.0	0	0	0	0	0	0	0	0	0
0.0	0	1	0	0	1	0	0	0	0
0.0	0	1	1	1	1	0	0	0	0
0.0	1	0	0	0	0	1	0	0	0
0.0	1	0	1	1	0	1	0	0	0
0.0	1	0	0	0	0	1	0	0	0
0.0	0	1	1	1	1	0	0	0	0
0.0	0	0	0	0	0	0	0	0	0

"THE CHESHIRE CAT"

1) SURVIVALS: ANY OCCUPIED CELL WITH 2

OR 3 NEIGHBORS REMAINS OCCUPIED.

2) DEATHS: ANY OCCUPIED CELL WITH LESS

THAN 2 NEIGHBORS BECOMES EMPTY DUE TO

ISOLATION. ANY OCCUPIED CELL WITH MORE THAN 3 NEIGHBORS DIES DUE TO OVERPOPULATION

3) BIRTHS: ANY EMPTY CELL WITH EXACTLY 3 NEIGHBORS BECOMES OCCUPIED.

NO CHANGES ARE MADE IN THE ARRAY UNTIL ALL CELLS HAVE BEEN SUBJECTED TO THESE RULES. FOR FASTEST TIME BETWEEN GENERATIONS, PLACE THE INITIAL CONFIGURATION TOWARDS THE BOTTOM AND LEFT BUT ALLOW ROOM FOR PATTERN GROWTH. MINIMUM TIME BETWEEN GENERATIONS IS 2 MINUTES, MAXIMUM TIME IS 9 MINUTES, AND AVERAGE TIME IS 5 TO 6 MINUTES.

Operating Limits and Warnings

ANY PATTERN THAT GROWS BEYOND THE LEFT BOUNDARY WILL GIVE INVALID RESULTS.

HP-67 USERS SHOULD CHANGE THE FOLLOWING PROGRAM STEPS IN THE LISTING:

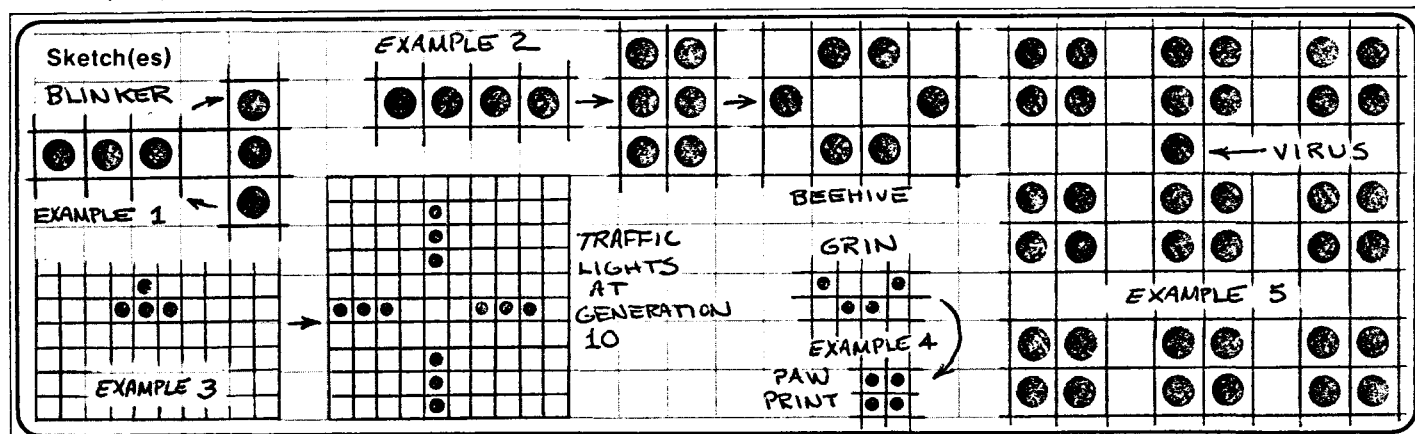
018 CHANGE -X- (PRINT X) 31 84 TO PAUSE 35 72

023 CHANGE -X- (PRINT X) 31 84 TO PAUSE 35 72

027 CHANGE -X- (PRINT X) 31 84 TO R/S 84

This program has been verified only with respect to the numerical example given in *Program Description II*. User accepts and uses this program material AT HIS OWN RISK, in reliance solely upon his own inspection of the program material and without reliance upon any representation or description concerning the program material.

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Sample Problem(s) (USE A SHEET OF GRAPH PAPER TO RECORD PATTERN CHANGES)

EXAMPLE 1: BLINKER CL REG, 0.111 STO 1, A

EXAMPLE 2: BEEHIVE CL REG, 0.1111 STO 1, A

EXAMPLE 3: TRAFFIC LIGHTS CL REG, 0.00111 STO 4, 0.0001 STO 5, A

EXAMPLE 4: CHESHIRE CAT CL REG, 0.001111 STO 1, STO 5

(SEE PAGE 1) 0.0100001 STO 2, STO 4

0.0101101 STO 3

0.001001 STO 6, A

EXAMPLE 5: VIRUS CL REG, 0.11011011 STO 1, STO 2, STO 4, STO 5, STO 7, STO 8

0.0001 STO 6, A

Solution(s)

EXAMPLE 1: THE PATTERN OSCILLATES BETWEEN 3 VERTICAL AND 3 HORIZONTAL CELLS.

EXAMPLE 2: THE PATTERN BECOMES A STABLE BEEHIVE AT GENERATION 2.

EXAMPLE 3: THE PATTERN BECOMES FOUR BLINKERS AT GENERATION 9.

EXAMPLE 4: THE CHESHIRE CAT FADES TO A GRIN AT GENERATION 6 AND
LEAVES A STABLE PAW PRINT AT GENERATION 7.

EXAMPLE 5: THE HOST IS KILLED OFF BY THE VIRUS UNTIL THE PATTERN
GROWS BEYOND THE ARRAY SIZE AT GENERATION 8.

Reference(s) MARTIN GARDNER, MATHEMATICAL GAMES, SCIENTIFIC
AMERICAN, OCT 1970 AND FEB 1971.

User Instructions

00626D



STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	LOAD SIDE 1 AND SIDE 2.			
2	CLEAR REGISTERS.		f Q REG	0
3	INPUT INITIAL CONFIGURATION, X=0,1:			
	ROW 0 X.XXXXXXXXXX	ROW 0	STO 0	ROW 0
	ROW 1 X.XXXXXXXXXX	ROW 1	STO 1	ROW 1
	ROW 2 X.XXXXXXXXXX	ROW 2	STO 2	ROW 2
	ROW 3 X.XXXXXXXXXX	ROW 3	STO 3	ROW 3
	ROW 4 X.XXXXXXXXXX	ROW 4	STO 4	ROW 4
	ROW 5 X.XXXXXXXXXX	ROW 5	STO 5	ROW 5
	ROW 6 X.XXXXXXXXXX	ROW 6	STO 6	ROW 6
	ROW 7 X.XXXXXXXXXX	ROW 7	STO 7	ROW 7
	ROW 8 X.XXXXXXXXXX	ROW 8	STO 8	ROW 8
	ROW 9 X.XXXXXXXXXX	ROW 9	STO 9	ROW 9
	(NEED NOT INPUT TRAILING ZEROS OR ALL ZERO ROWS).			
4	START.		A	
97	THE HP-97 WILL NOW SUCCESSIVELY PRINT:			
	GENERATION NUMBER,			GEN
	10 X 10 ARRAY (ROW 9 AT TOP).			ARRAY
67	THE HP-67 WILL PAUSE TO DISPLAY THE FOLLOWING:			
	GENERATION NUMBER,			GEN
	ROW 9, ROW 8, ..., ROW 2, ROW 1,			ROW
	AND WILL STOP WITH ROW 0 IN THE DISPLAY.			ROW 0
5	TO DISPLAY THE ROWS SEPARATELY: (ANY ORDER)			
	ROW 0		RCL 0	ROW 0
	ROW 1		RCL 1	ROW 1
	ROW 2		RCL 2	ROW 2
	ROW 3		RCL 3	ROW 3
	ROW 4		RCL 4	ROW 4
	ROW 5		RCL 5	ROW 5
	ROW 6		RCL 6	ROW 6
	ROW 7		RCL 7	ROW 7
	ROW 8		RCL 8	ROW 8
	ROW 9		RCL 9	ROW 9
6	COMPUTE NEXT GENERATION		R/S	
	GO TO STEP 67			
	FOR A NEW INITIAL CONFIGURATION, GO TO			
	STEP 2.			

STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBL A	31 25 11	START		ISZ	31 34	
	PZS	31 42			GTO 2	22 02	
	CL REG	31 43			*LBL 3	31 25 03	BUILD LAST ROW
	DSZ	31 33			RCL O	34 00	SHOWING VERTICAL
	*LBL O	31 25 00	SET UP ROW COUNTER		+	61	NEIGHBORS AND
	PZS	31 42			RC I	35 34	UPDATE ROW
	1	01			CL REG	31 43	COUNTER
	0	00			9	09	
	RC I	35 34			PZS	31 42	
010	+	61			+	61	
	ST I	35 33			ST I	35 33	
	FRAC	32 83	EXTRACT AND PRINT		R↓	35 53	
	EEX	43	GENERATION		STO O	33 00	
	5	05	NUMBER	070	1	01	
	X	71			STO E	33 15	
HP-67	SPACE	35 84			*LBL 4	31 25 04	BEGIN TESTING
↓	DSP O	23 00			RCL A	34 11	TO COUNT TOTAL
PAUSE	-X-	31 84			STO B	33 12	NEIGHBORS TO
	DSP 9	23 09	PRINT ARRAY		RCL C	34 13	APPLY GENETIC
020	SPACE	35 84	STARTING WITH		STO A	33 11	RULES FOR EACH
HP-67	*LBL 1	31 25 01	ROW 9		RCL (i)	34 24	ROW A CELL AT
↓	RCL (i)	34 24			F? O	35 71 00	A TIME
PAUSE	-X-	31 84			CF 1	35 61 01	
	DSZ	31 33		080	X=O	31 51	
HP-67	GTO 1	22 01			SF O	35 51 00	
↓	RCL O	34 00			INT	31 83	
R/S	-X-	31 84			STO C	33 13	
	RC I	35 34	UPDATE ROW		LST X	35 82	
	9	09	COUNTER		FRAC	32 83	
030	+	61			1	01	
	EEX	43	INCREMENT		0	00	
	CHS	42	GENERATION		X	71	
	5	05	NUMBER		STO (i)	33 24	
	+	61		090	0	00	
	ST I	35 33			STO D	33 14	
	RCL 8	34 08	REBUILD EACH		RCL C	34 13	ROUTINE TO
	2	02	ROW SO THAT IT		X=O	31 51	DETERMINE
	X	71	CONTAINS INFORMATION		GTO 5	22 05	SURVIVAL
	*LBL 2	31 25 02	SHOWING HOW MANY		3	03	
040	RCL (i)	34 24	VERTICAL NEIGHBORS		X>Y	32 81	
	+	61	IT HAS		GTO 6	22 06	
	PZS	31 42			CLX	44	
	STO (i)	33 24			5	05	
	PZS	31 42		100	X=Y	32 51	
	RCL (i)	34 24			GTO 7	22 07	
	2	02			RCL D	34 14	
	X	71			2	02	
	DSZ	31 33			+	61	
	X<O	31 71			STO D	33 14	
050	GTO 3	22 03			GTO 5	22 05	
	DSZ	31 33			*LBL 6	31 25 06	
	DEG	35 41			RCL D	34 14	
	RCL (i)	34 24			1	01	
	2	02		110	+	61	
	X	71			STO D	33 14	
	+	61			GTO 5	22 05	

REGISTERS

0 ROW 0	1 ROW 1	2 ROW 2	3 ROW 3	4 ROW 4	5 ROW 5	6 ROW 6	7 ROW 7	8 ROW 8	9 ROW 9
S0 ROW 0'	S1 ROW 1'	S2 ROW 2'	S3 ROW 3'	S4 ROW 4'	S5 ROW 5'	S6 ROW 6'	S7 ROW 7'	S8 ROW 8'	S9 ROW 9'
A USED	B USED	C USED	D USED	E USED	I USED				

STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
	*LBL 7	31 25 07			3	03	
	RCL D	34 14		170	+	61	
	3	03			STD D	33 14	
	+	61			*LBL b	32 25 12	TEST TO
	STD D	33 14			RCL A	34 11	DETERMINE IF
	*LBL 5	31 25 05			2	02	CELL IS TO BE
	RCL A	34 11			÷	81	OCCUPIED DUE TO
120	X=0	31 51			FRAC	32 83	BIRTH
	GTO 8	22 08			X=0	31 51	
	3	03			GTO e	22 31 15	
	X>Y	32 81			4	04	
	GTO 9	22 09		180	RCL D	34 14	
	CLX	44			X=Y	32 51	
	5	05			SF 2	35 51 02	
	X=Y	32 51			*LBL e	32 25 15	DECIDE IF CELL
	GTO a	22 31 11			3	03	IS TO BE EMPTY
	RCL D	34 14			RCL D	34 14	(0) OR OCCUPIED (1)
130	2	02			X=Y	32 51	
	+	61			SF 2	35 51 02	
	STD D	33 14			0	00	
	GTO 8	22 08			F? 2	35 71 02	
	*LBL 9	31 25 09		190	1	01	
	RCL D	34 14			PZS	31 42	ADD CONDITION OF
	1	01			1	01	TESTED CELL TO
	+	61			0	00	THE END OF THE
	STD D	33 14			STD X (i)	33 71 24	CURRENT ROW
	GTO 8	22 08			XZY	35 52	BEING
140	*LBL a	32 25 11			STD + (i)	33 61 24	CONSTRUCTED
	RCL D	34 14			PZS	31 42	
	3	03			R↓	35 53	KEEP TRACK OF
	+	61			RCL E	34 15	DECIMAL POINT IN
	STD D	33 14			X	71	ROW BEING
	*LBL 8	31 25 08		200	STD E	33 15	CONSTRUCTED
	RCL B	34 12			F? 1	35 71 01	IF NOT LAST CELL,
	X=0	31 51			GTO 4	22 04	GO TO STEP 4
	GTO b	22 31 12			PZS	31 42	POSITION DECIMAL
	3	03			RCL (i)	34 24	POINT IN ROW
150	X>Y	32 81			RCL E	34 15	WHICH HAS JUST
	GTO c	22 31 13			÷	81	BEEN FINISHED
	CLX	44			EEX	43	ACCORDING TO THE
	5	05			2	02	GENETIC RULES
	X=Y	32 51			X	71	
	GTO d	22 31 14		210	STD (i)	33 24	
	RCL D	34 14			PZS	31 42	
	2	02			CF 0	35 61 00	SET INITIAL
	+	61			SF 1	35 51 01	CONDITIONS
	STD D	33 14			DSZ	31 33	TEST TO SEE IF
160	GTO b	22 31 12			RC I	35 34	THIS IS THE LAST
	*LBL c	32 25 13			RC I	35 34	ROW OF THE ARRAY,
	RCL D	34 14			X<0	31 71	IF SO, GO TO THE
	1	01			GTO 0	22 00	PRINT ROUTINE
	+	61			0	00	ELSE, GO TO LBL 4
	STD D	33 14		220	STD B	33 12	TO BEGIN GENETIC
	GTO b	22 31 12			1	01	TESTING OF NEXT
	*LBL d	32 25 14			STD E	33 15	ROW
	RCL D	34 14			GTO 4	22 04	

ROUTINE TO
DETERMINE
BIRTH

LABELS					FLAGS		SET STATUS		
A	B	C	D	E	0	USED	FLAGS	TRIG	DISP
START							ON OFF		
USED	USED	USED	USED	USED	1	USED	0 ☐ ☒	DEG ☒	FIX ☒
0 USED	1 USED	2 USED	3 USED	4 USED	2	USED	1 ☒ ☐	GRAD ☐	SCI ☐
5 USED	6 USED	7 USED	8 USED	9 USED	3		2 ☐ ☒	RAD ☐	ENG ☐
							3 ☐ ☒		n 9