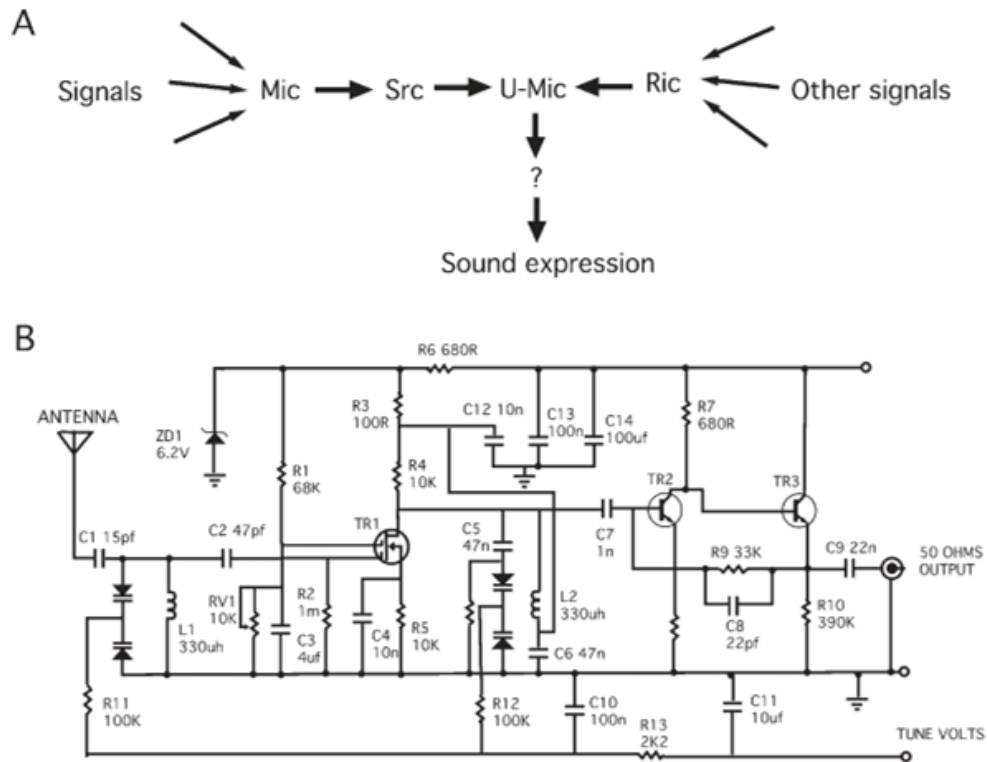


La biología como sistema dinámico



(Lazebnik 2002)

Interaccione



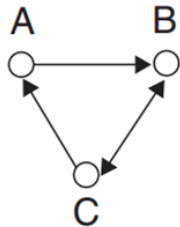
Propiedades
Emergentes

Sistema
(formalizar)

Redes Booleanas

$$x_n(t + \tau) = F_n(x_{n_1}(t), x_{n_2}(t), \dots, x_{n_k}(t)).$$

(a) Network



(b) Updating functions

$$\begin{aligned} B_A &= S_C \\ B_B &= S_A \text{ OR } S_C \\ B_C &= S_B \end{aligned}$$

(c) Truth tables

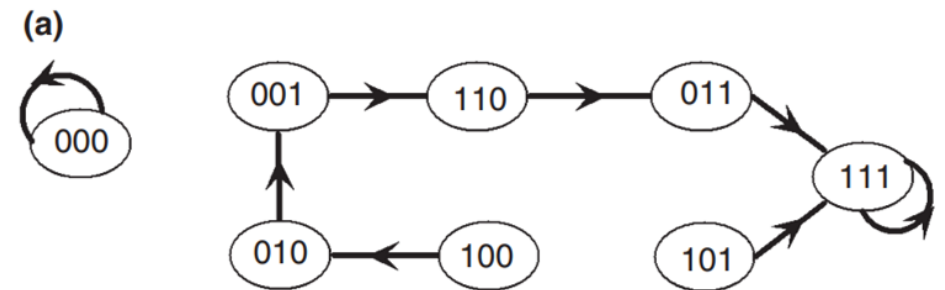
S_C	B_A
0	0
1	1

S_A	S_C	B_B
0	0	0
0	1	1
1	0	1
1	1	1

S_A	B_B
0	0
1	1

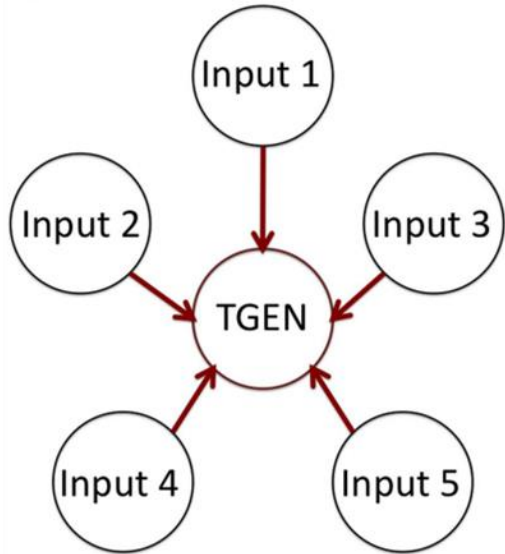
Supuestos:

- 1) $x_i = \{0, 1\}$
- 2) $t = \{0, 1, \dots, n\}$
- 3) AND (&), OR (|), NOT (!)



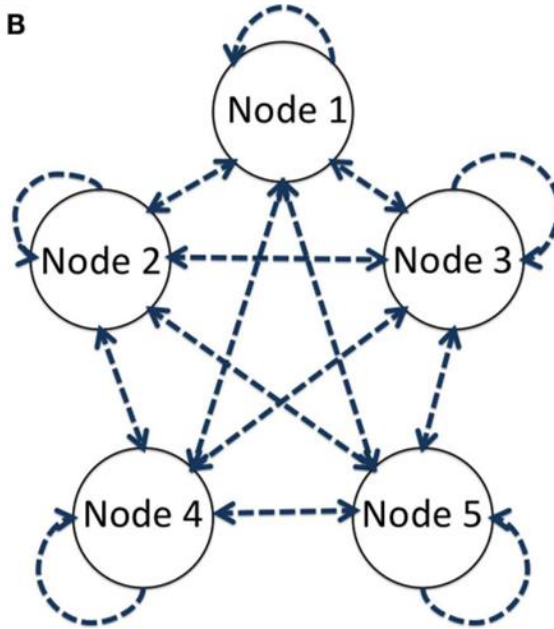
Significancia Biológica

A



In 1	In 2	In 3	In 4	In 5	TGEN
0	0	0	0	0	*
0	0	0	0	1	*
.
.
1	1	1	1	0	*
1	1	1	1	1	*

B



	N1	N2	N3	N4	N5
N1	*	*	*	*	*
N2	*	*	*	*	*
N3	*	*	*	*	*
N4	*	*	*	*	*
N5	*	*	*	*	*

Condiciones
iniciales: 2^n
Funciones
Booleanas: 2^{2^i}
Topologías: 2^{n^2}

(Azpeitia et al. 2013)

Atractor:

$$\bar{x}_{(t)} = \bar{x}_{(t+1)}$$

a

Time	GEN1	GEN2	GEN3
1	1	0	0
2	1	0	0
3	1	0	0
.			
.			
.			
n-1	1	0	0
n	1	0	0

Fixed-point attractor

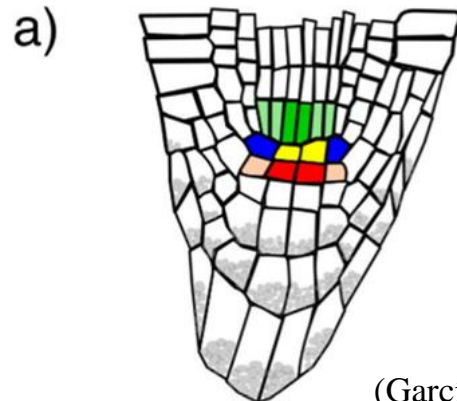
b

Time	GEN1	GEN2	GEN3
1	0	1	1
2	1	0	1
3	0	1	1
.			
.			
.			
n-1	1	0	1
n	0	1	1

Cyclic attractor

(Azpeitia et al. 2014)

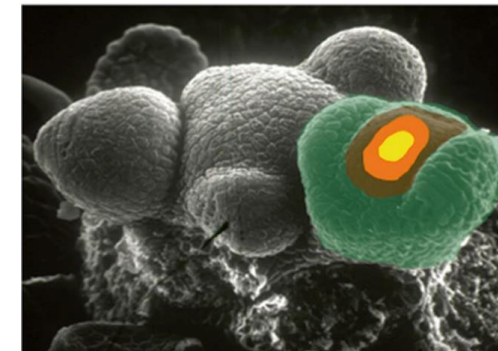
Propiedades Emergentes = Fenotipos



b)

Quiescent center	011101101110110000
P. provascular initials	001000101111110000
C. provascular initials	001000011111110000
Cortex/end. initials	001111101110010000
Columella initials	100000101111110011
Transition domain	100000011111110011

(García-Gómez et al. 2020)



c

A	A+B	B+C	C
01100110000011	011001101110011	011011101110110	011011101100110
01100110000011	011001101111011	011011101111110	011011101100110

(Azpeitia et al. 2014)