GENETIC CIRCUITS

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CONTENT

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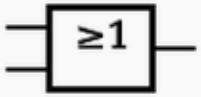
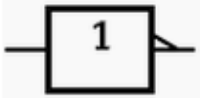
LOGIC GATES

- "A **logic gate** is an idealized or physical device implementing a Boolean function."

- "It performs a logical operation on one or more logical inputs, and produces a single logical output.".

- "A **Boolean function** (or switching function) is a function of the form $f : \mathbf{B}^k \rightarrow \mathbf{B}$, where $\mathbf{B} = \{0, 1\}$ is a *Boolean domain* and k is a non-negative integer."

LOGIC GATES (2)

Type	Distinctive shape	Rectangular shape	Boolean algebra	Truth table
AND			$A \cdot B$	INPUT / OUTPUT A B A AND B 0 0 0 0 1 0 1 0 0 1 1 1
OR			$A + B$	INPUT / OUTPUT A B A OR B 0 0 0 0 1 1 1 0 1 1 1 1
NOT			$\overline{A}$	INPUT / OUTPUT A NOT A 0 1 1 0

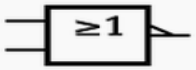
LOGIC GATES (3)

NAND

$\overline{A \cdot B}$

INPUT		OUTPUT
A	B	A NAND B
0	0	1
0	1	1
1	0	1
1	1	0

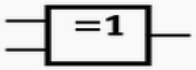
NOR



$\overline{A + B}$

INPUT		OUTPUT
A	B	A NOR B
0	0	1
0	1	0
1	0	0
1	1	0

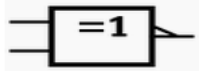
XOR



$A \oplus B$

INPUT		OUTPUT
A	B	A XOR B
0	0	0
0	1	1
1	0	1
1	1	0

XNOR



$\overline{A \oplus B}$ or $A \odot B$

INPUT		OUTPUT
A	B	A XNOR B
0	0	1
0	1	0
1	0	0
1	1	1

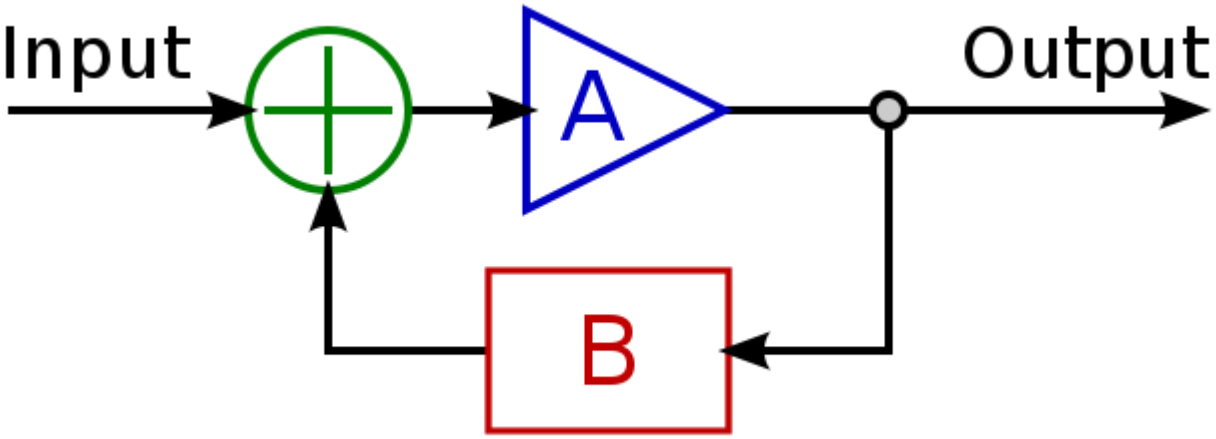
FEEDBACK

- **Feedback** is a process in which information about the past or the present influences the same phenomenon in the present or future.

- Divided into two types:

    - *Positive*
    - *Negative*

POSITIVE FEEDBACK



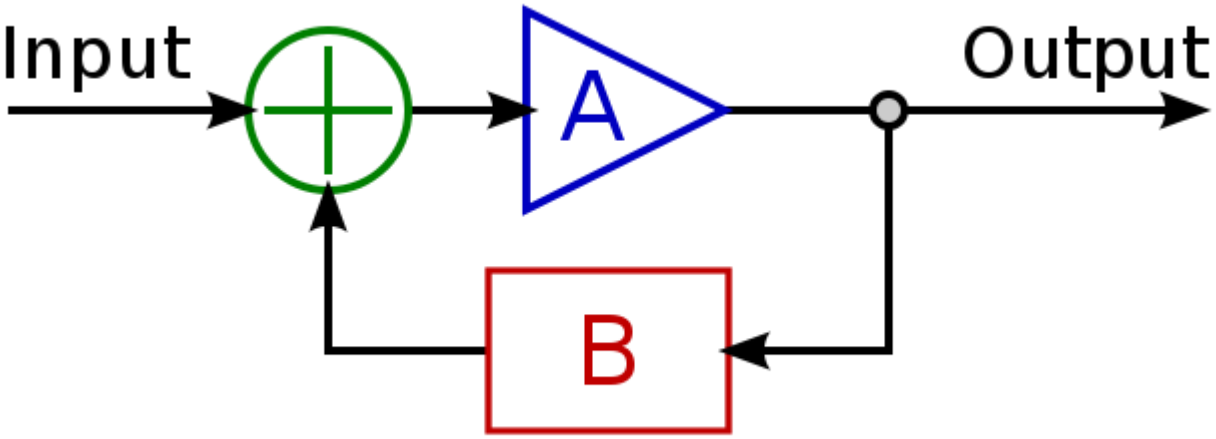
- The result of positive feedback is to augment changes, so that small perturbations may result in big changes.

POSITIVE FEEDBACK (2)

- “Positive feedback loops are sources of growth, explosion, erosion, and collapse in systems. A system with an unchecked positive loop ultimately will destroy itself. That’s why there are so few of them. Usually a negative loop will kick in sooner or later.”

Donella Meadows

NEGATIVE FEEDBACK



- Negative feedback tends to make a system self-regulating; it can produce stability and reduce the effect of fluctuations.

HYSTERESIS

- **Hysteresis** is the dependence of a system not only on its current environment but also on its past environment.

- This dependence arises because the system can be in more than one internal state.

OPERON

- "An **operon** is a functioning unit of DNA containing a cluster of genes under the control of a single regulatory signal or promoter."

- "The genes are transcribed together into an mRNA strand and either translated together."

- An operon is made up of 3 basic components.

OPERON (2)

- Promoter : a nucleotide sequence that enables a gene to be transcribed.

- Operator : a segment of DNA that a regulator binds to. It is classically defined in the lac operon as a segment between the promoter and the genes of the operon.

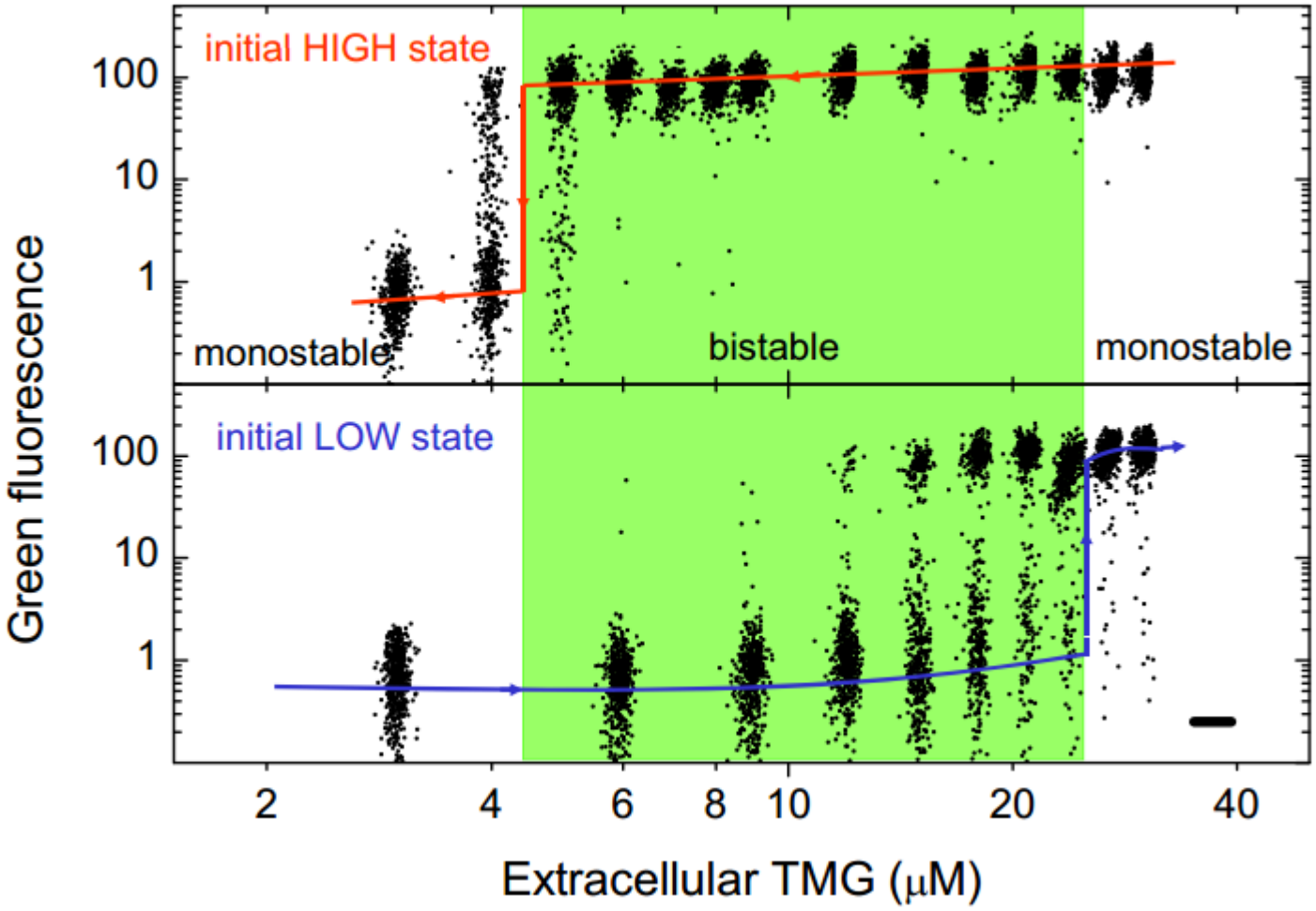
- Structural genes – the genes that are co-regulated by the operon.

LAC OPERON

- The ***lac* operon** is an operon required for the transport and metabolism of lactose in *Escherichia coli* and some other enteric bacteria.

- The genes encode ß-galactosidase, lactose permease, and thiogalactoside transacetylase.

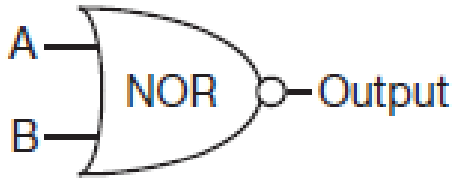
HYSTERESIS AND LAC OPERON



LOGIC GATES AND GENES

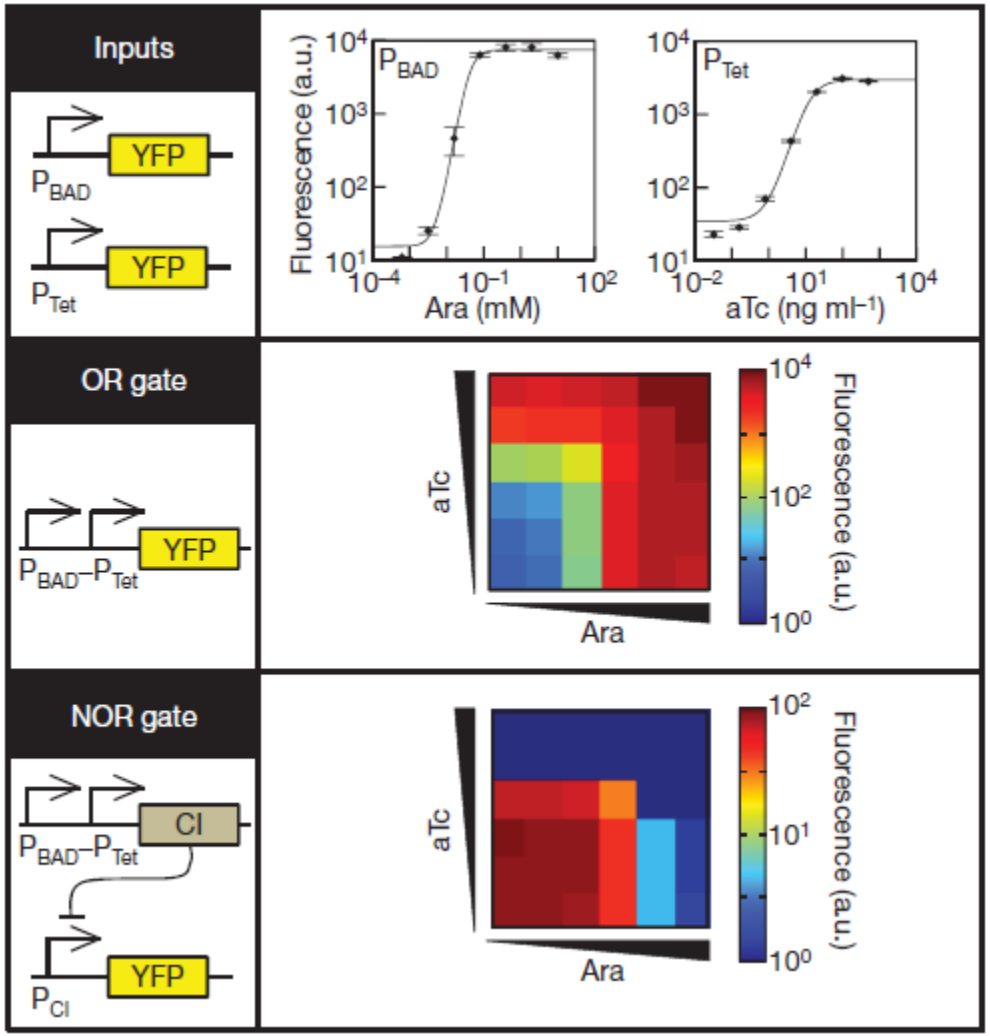
- The genetic NOR gate.

- A NOR gate is ‘on’only when both inputs are ‘off’.

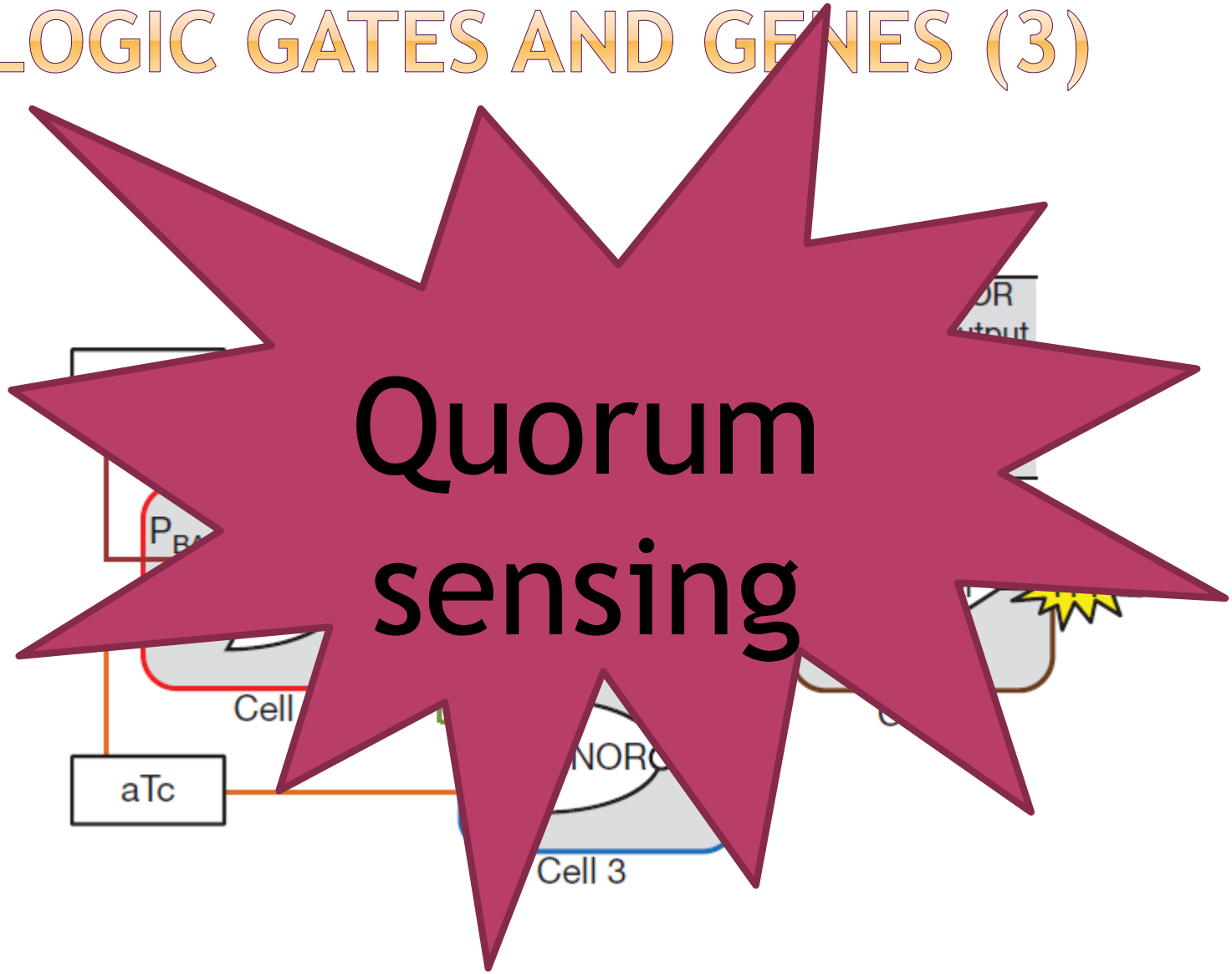


Inputs		
in1	in2	Output
0	0	1
0	1	0
1	0	0
1	1	0

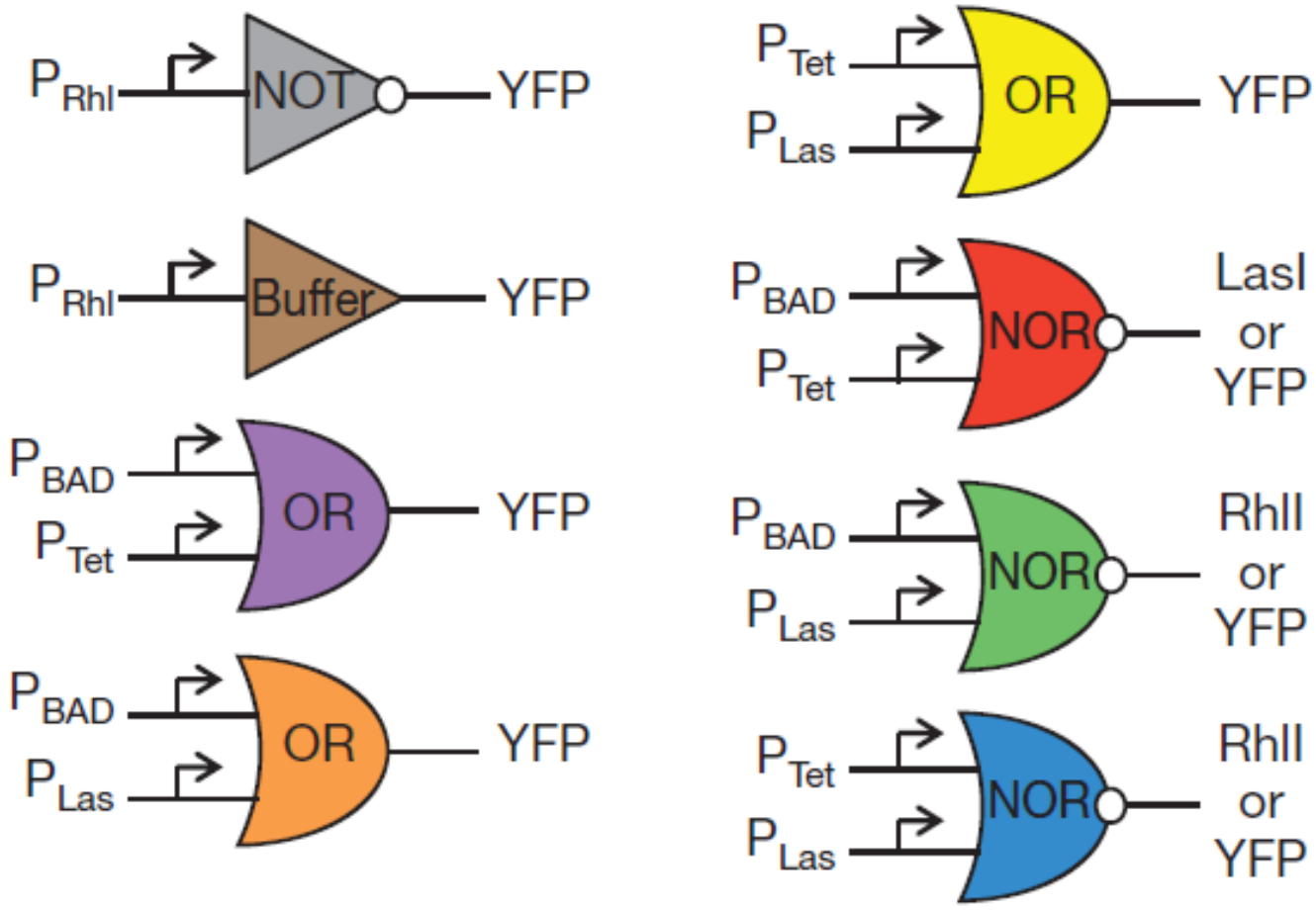
LOGIC GATES AND GENES (2)



LOGIC GATES AND GENES (3)



LOGIC GATES AND GENES (4)



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