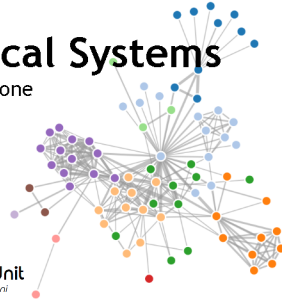


# Modelling Biological Systems

Alberto Calderone



Bioinformatics and Computational Biology Unit  
Molecular Genetics Laboratory - University of Rome Tor Vergata - prof. Gianni Cesareni

---

---

---

---

---

---

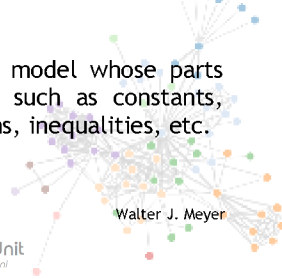
---

---

## What is a Model?

A **model** is an object or concept that is used to represent something else. It is reality scaled down and converted to a form we can comprehend.

A **mathematical model** is a model whose parts are mathematical concepts, such as constants, variables, functions, equations, inequalities, etc.



Walter J. Meyer

Bioinformatics and Computational Biology Unit  
Molecular Genetics Laboratory - University of Rome Tor Vergata - prof. Gianni Cesareni

---

---

---

---

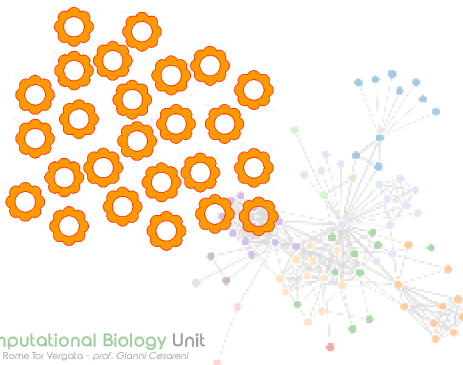
---

---

---

---

## Difference Model



Bioinformatics and Computational Biology Unit  
Molecular Genetics Laboratory - University of Rome Tor Vergata - prof. Gianni Cesareni

---

---

---

---

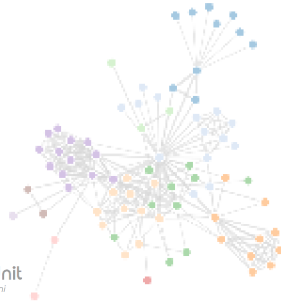
---

---

---

---

## Difference Model



Bioinformatics and Computational Biology Unit  
Molecular Genetics Laboratory - University of Rome Tor Vergata - prof. Gianni Cesareni

---

---

---

---

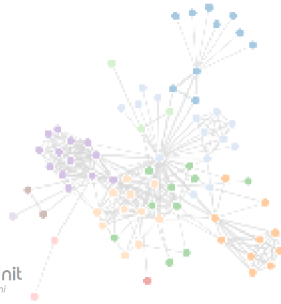
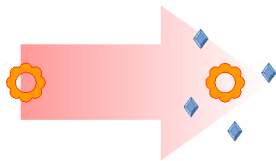
---

---

---

---

## Difference Model



Bioinformatics and Computational Biology Unit  
Molecular Genetics Laboratory - University of Rome Tor Vergata - prof. Gianni Cesareni

---

---

---

---

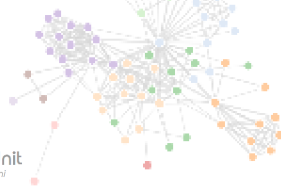
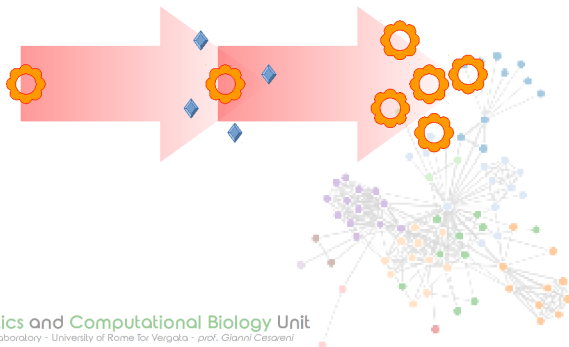
---

---

---

---

## Difference Model



Bioinformatics and Computational Biology Unit  
Molecular Genetics Laboratory - University of Rome Tor Vergata - prof. Gianni Cesareni

---

---

---

---

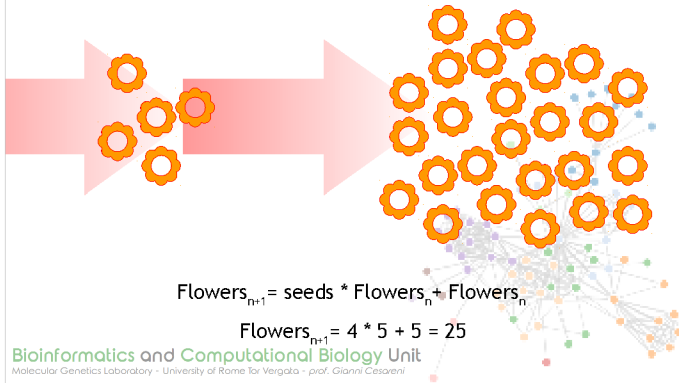
---

---

---

---

## Difference Model




---

---

---

---

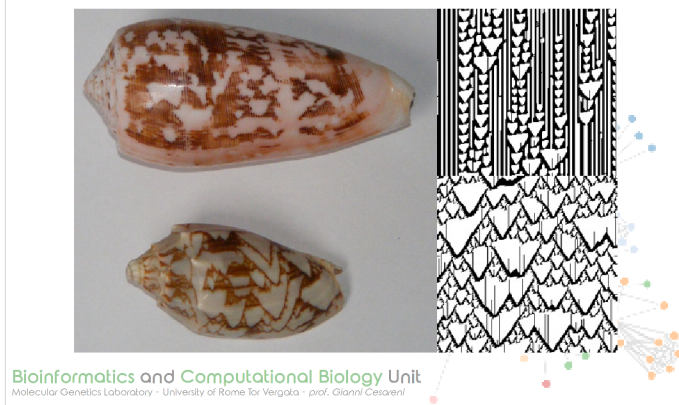
---

---

---

---

## Cellular Automata




---

---

---

---

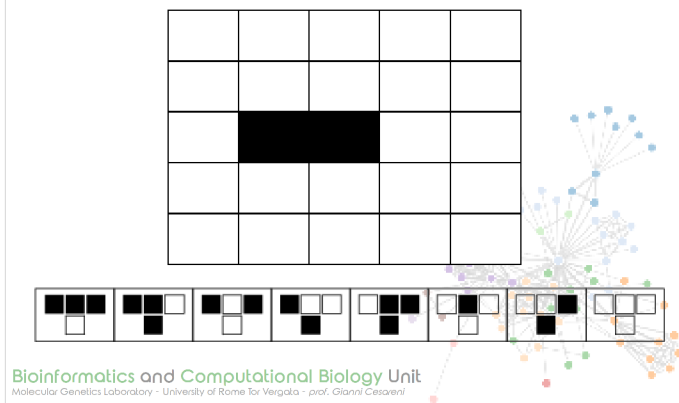
---

---

---

---

## Cellular Automata




---

---

---

---

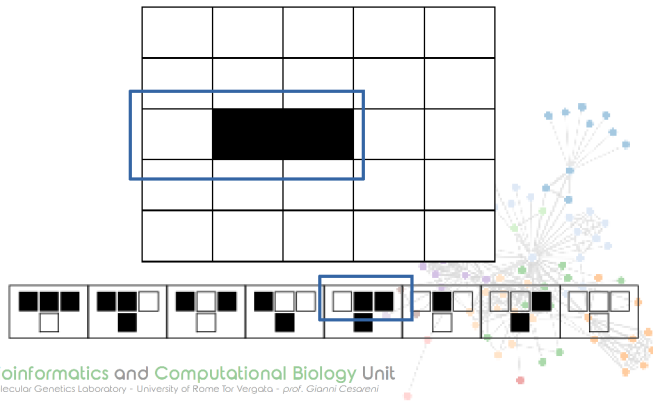
---

---

---

---

## Cellular Automata



---

---

---

---

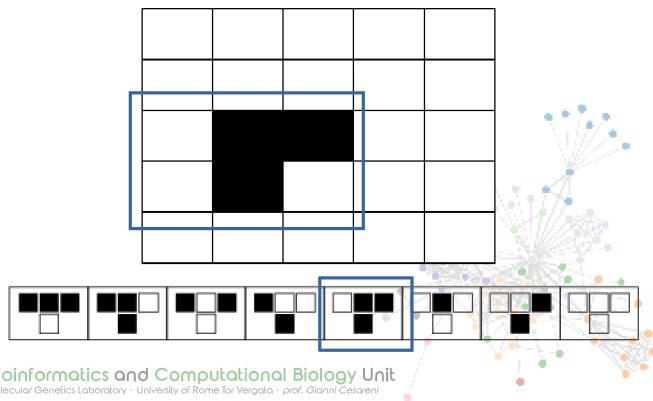
---

---

---

---

## Cellular Automata



---

---

---

---

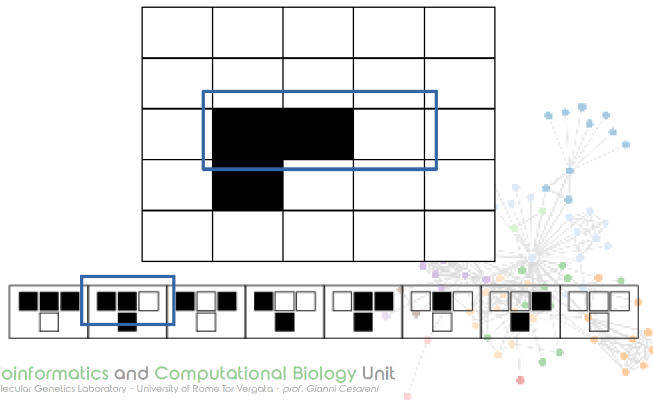
---

---

---

---

## Cellular Automata



---

---

---

---

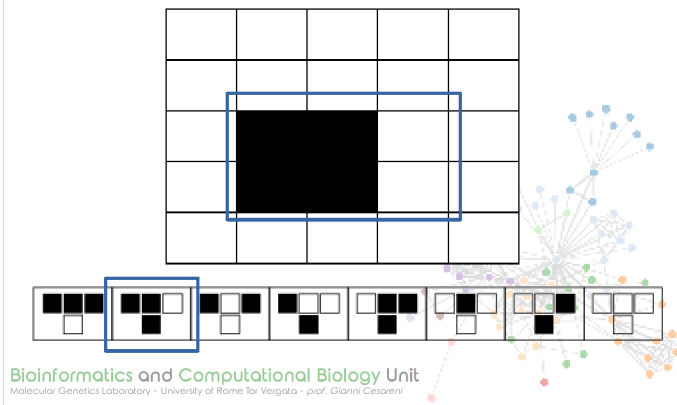
---

---

---

---

## Cellular Automata



---

---

---

---

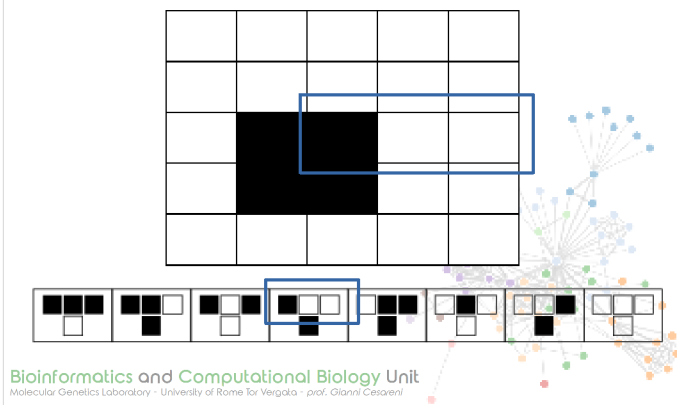
---

---

---

---

## Cellular Automata



---

---

---

---

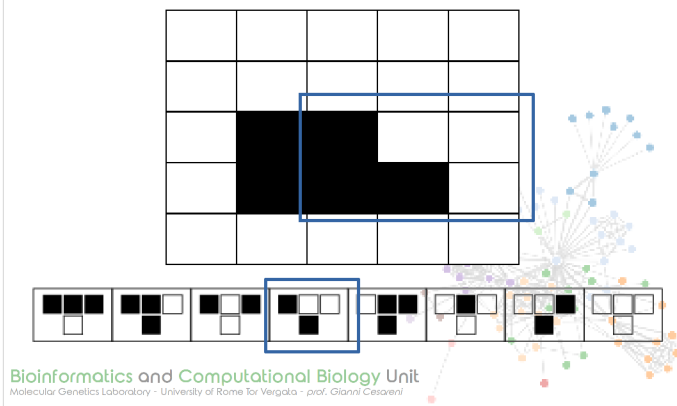
---

---

---

---

## Cellular Automata



---

---

---

---

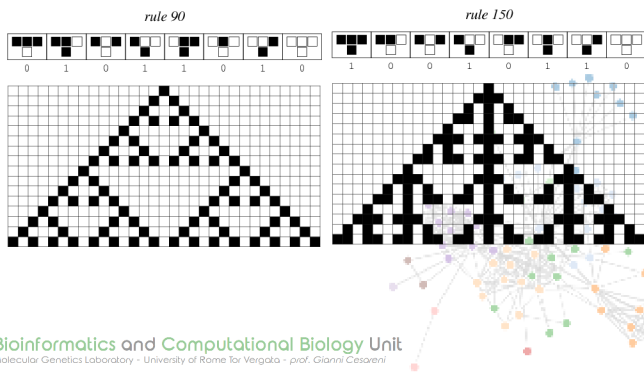
---

---

---

---

## Cellular Automata




---

---

---

---

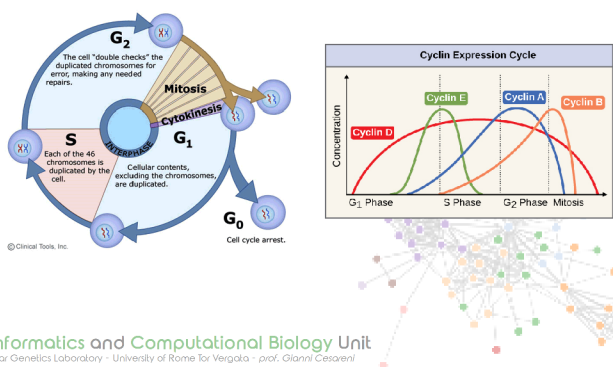
---

---

---

---

## Boolean Network




---

---

---

---

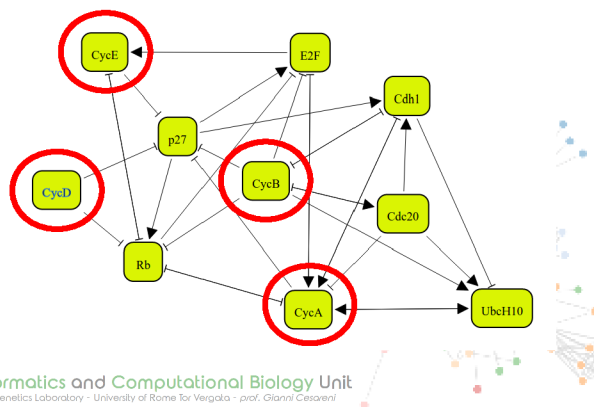
---

---

---

---

## Boolean Network




---

---

---

---

---

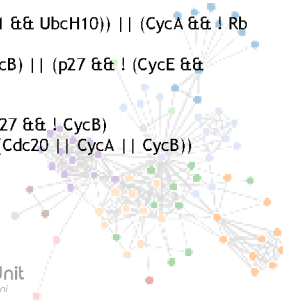
---

---

---

## Boolean Network

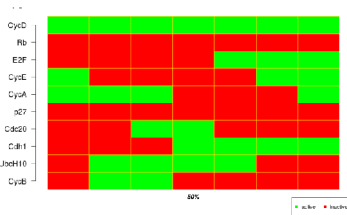
$CycD = CycD$   
 $Rb = (! CycA \ \&\& ! CycB \ \&\& ! CycD \ \&\& ! CycE) \ || \ (p27 \ \&\& ! CycB \ \&\& ! CycD)$   
 $E2F = (! Rb \ \&\& ! CycA \ \&\& ! CycB) \ || \ (p27 \ \&\& ! Rb \ \&\& ! CycB)$   
 $CycE = (E2F \ \&\& ! Rb)$   
 $CycA = (E2F \ \&\& ! Rb \ \&\& ! Cdc20 \ \&\& ! (Cdh1 \ \&\& UbcH10)) \ || \ (CycA \ \&\& ! Rb \ \&\& ! Cdc20 \ \&\& ! (Cdh1 \ \&\& UbcH10))$   
 $p27 = (! CycD \ \&\& ! CycE \ \&\& ! CycA \ \&\& ! CycB) \ || \ (p27 \ \&\& ! (CycE \ \&\& CycA) \ \&\& ! CycB \ \&\& ! CycD)$   
 $Cdc20 = CycB$   
 $Cdh1 = (! CycA \ \&\& ! CycB) \ || \ (Cdc20) \ || \ (p27 \ \&\& ! CycB)$   
 $UbcH10 = ! Cdh1 \ || \ (Cdh1 \ \&\& UbcH10 \ \&\& (Cdc20 \ || \ CycA \ || \ CycB))$   
 $CycB = ! Cdc20 \ \&\& ! Cdh1$



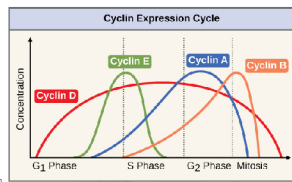
Bioinformatics and Computational Biology Unit  
 Molecular Genetics Laboratory - University of Rome Tor Vergata - prof. Gianni Cesareni

## Boolean Network

Boolean



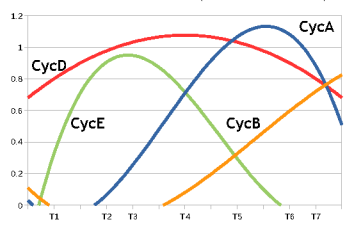
Reality



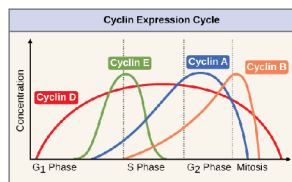
Bioinformatics and Computational Biology Unit  
 Molecular Genetics Laboratory - University of Rome Tor Vergata - prof. Gianni Cesareni

## Boolean Network

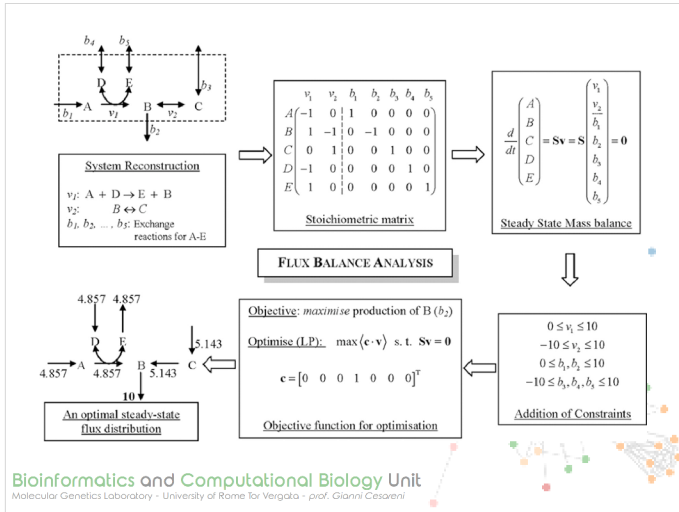
Boolean (Continuous)



Reality



Bioinformatics and Computational Biology Unit  
 Molecular Genetics Laboratory - University of Rome Tor Vergata - prof. Gianni Cesareni




---

---

---

---

---

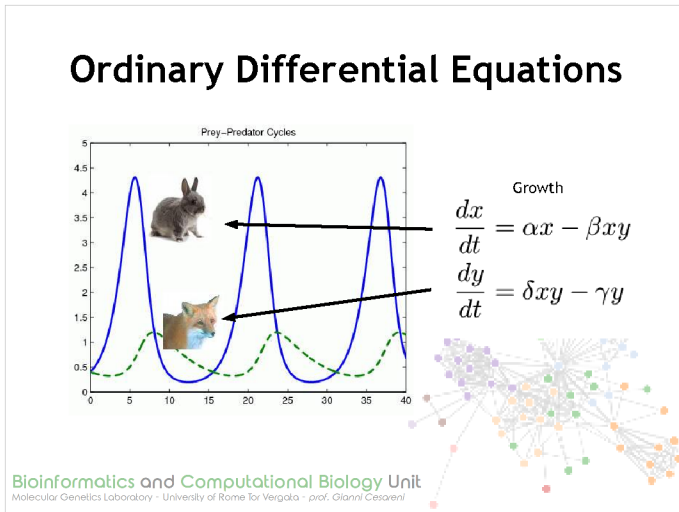
---

---

---

---

---




---

---

---

---

---

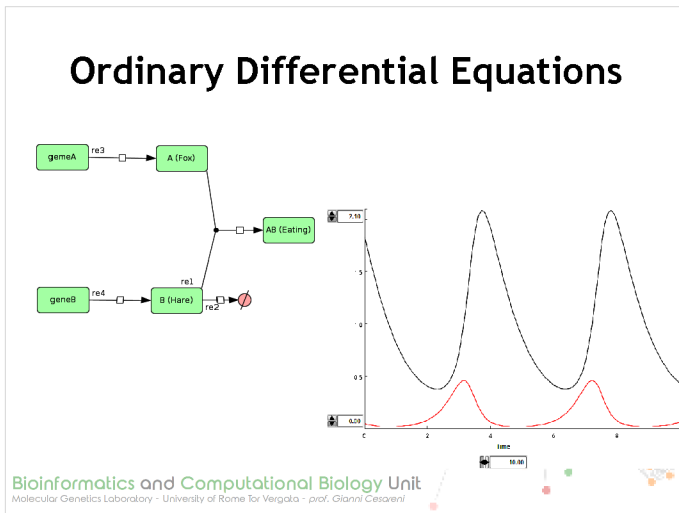
---

---

---

---

---




---

---

---

---

---

---

---

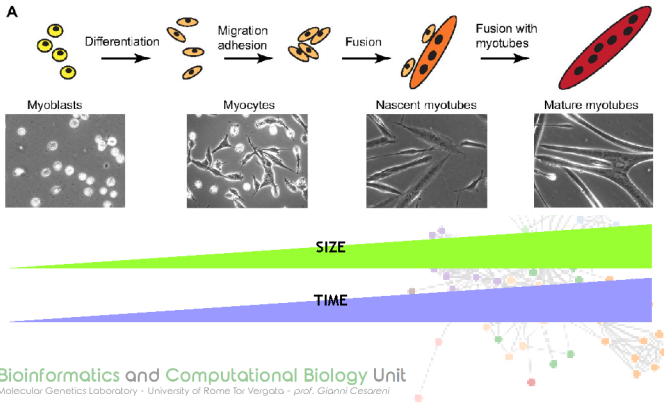
---

---

---



## Going Beyond one Scale



---

---

---

---

---

---

---

---