LODHA genius PROGRAMME | ASHOKA UNIVERSITY

Biological Modeling

Sudipta Tung

Computational/Mathematical Model

A mathematical, logical, or graphical representation/abstraction

of a system/process

a set of descriptors/variables

depicting relationships between them

describe and predict some aspects of the system/process

<Time>

Moose Population

Wolf Population

A mathematical, logical, or graphical representation

of a system/process

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describe and predict some aspects of the system/process

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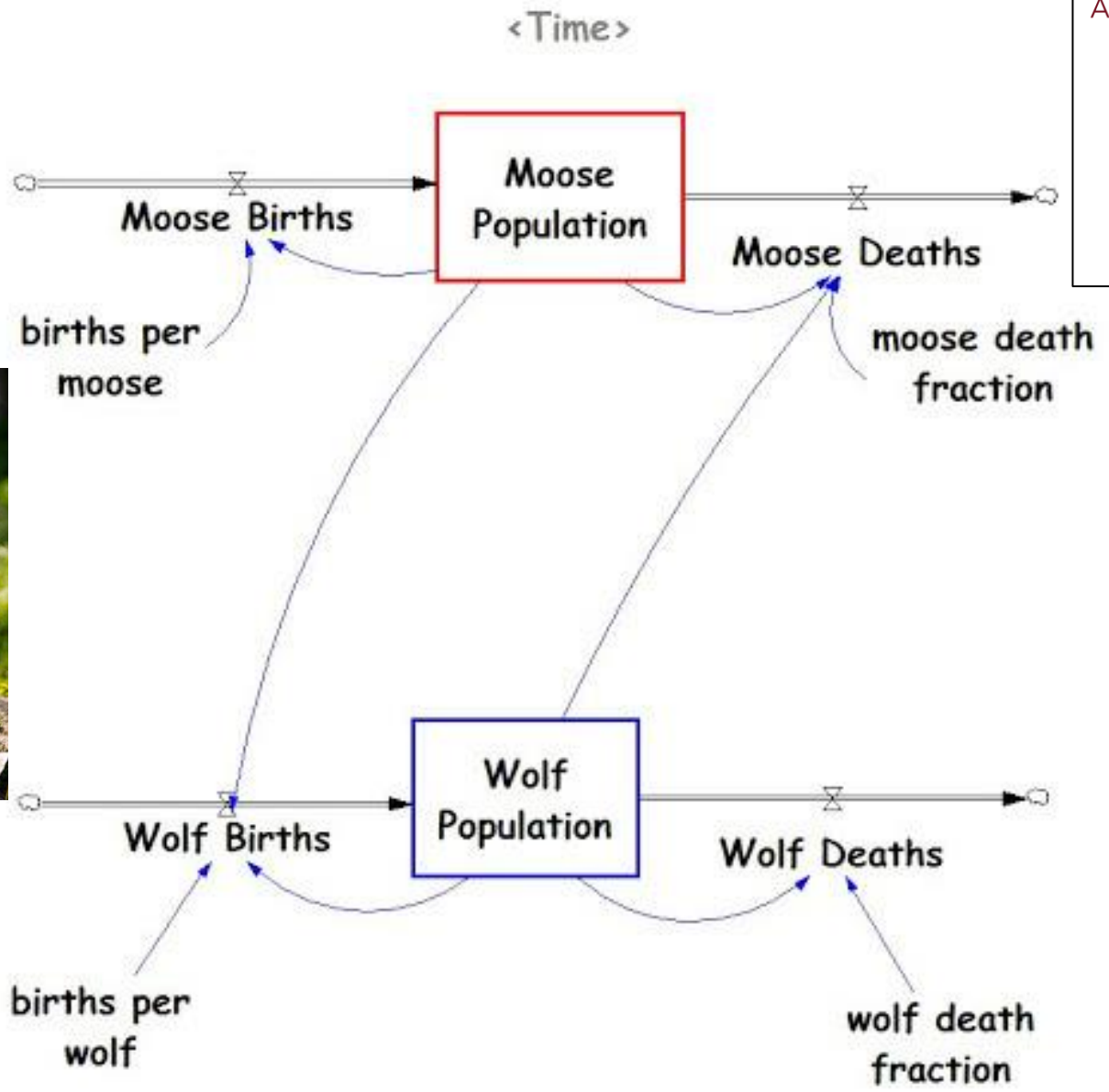

Feedback Loop

Why model? The 2 Feedback Loop Limitation

Humans unaided **CAN** predict behaviour of simple situations

with **less than 2 feedback loops**

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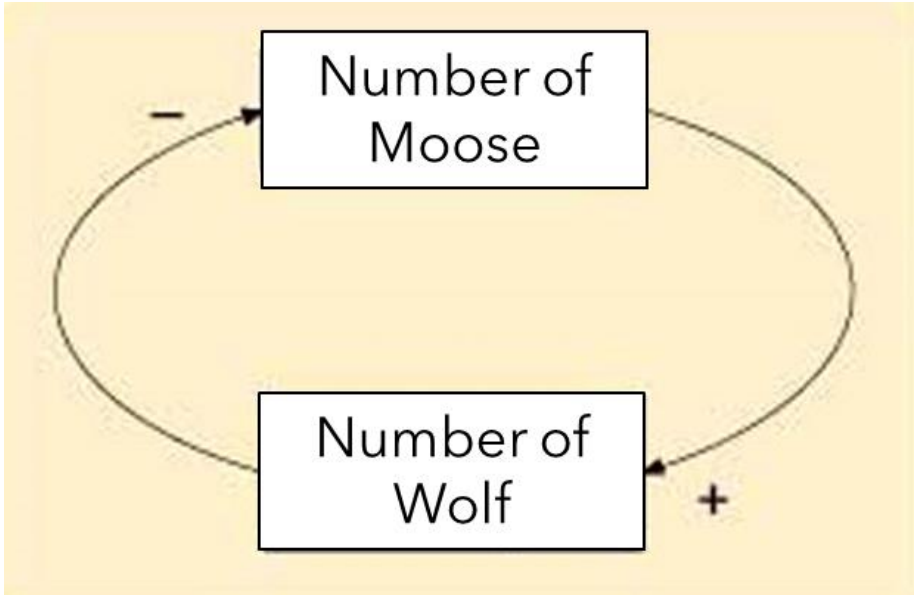
Humans unaided **CANNOT** predict behaviour of complex situations

with **2 or more feedback loops**



Dr. Terence Love, 2009

Two categories

- **Phenomenological models**

  Overall phenomenon is in focus;
  features of individual entities do not matter

- **Agent-based models**

  Features of individual entities are in focus

Phenomenological model:
Modelling Population Growth

Agent-based model:
Modelling The Game of Life

Rules of the game

Premise

- Each cell has 8 neighbours
- Each cell – alive or dead, 2 states

Rules

- ***Alive***: if 3 neighbours are alive
- ***Stay alive***: if 2 or 3 neighbours are alive
- ***Dead***: otherwise

1	2	3	4	5
6	7	8	9	10
11	12	13	14	15
16	17	18	19	20
21	22	23	24	25

Let's play the game

Rules

- ***Alive***: if 3 neighbours are alive
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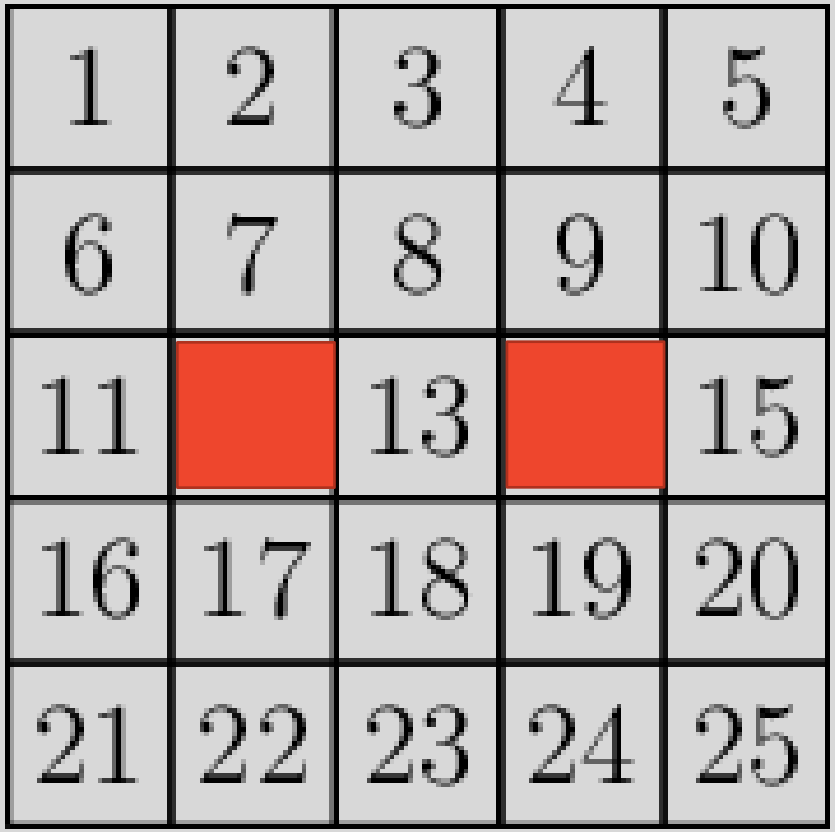

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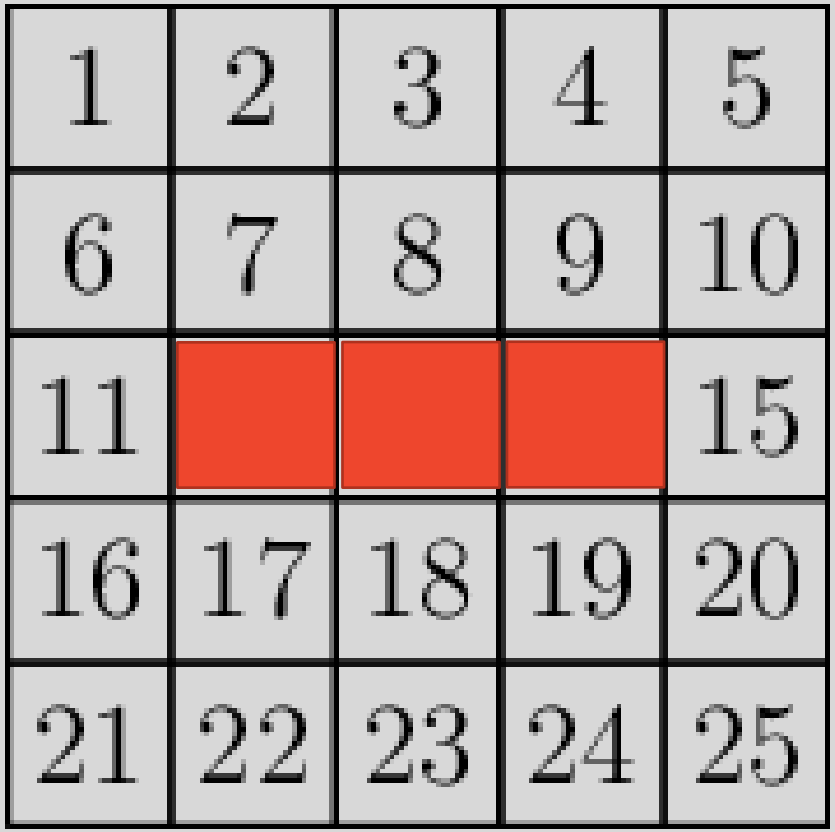

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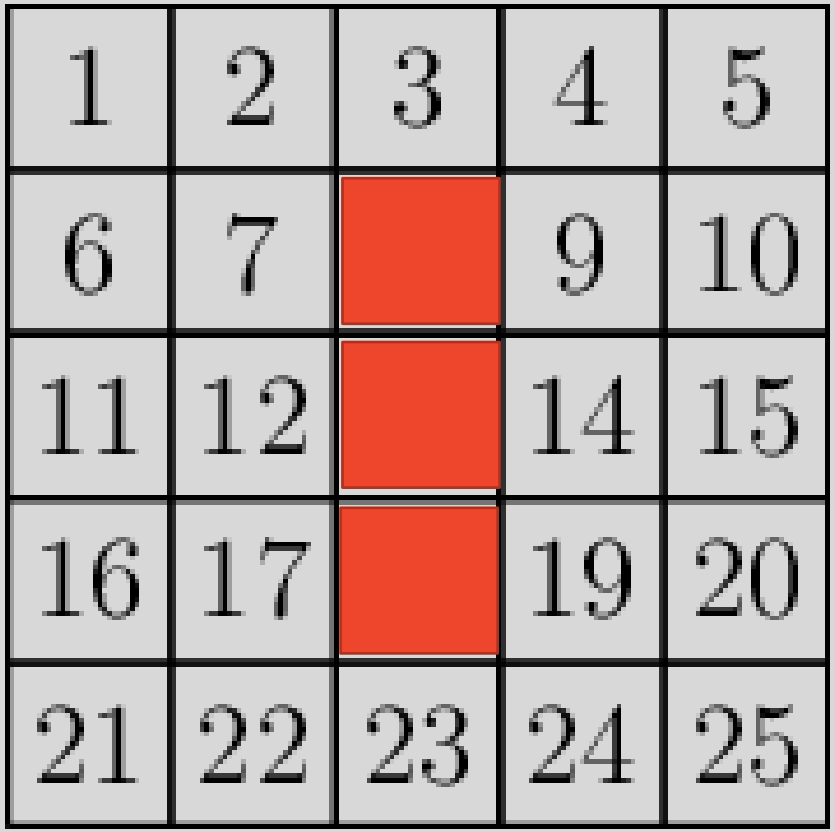

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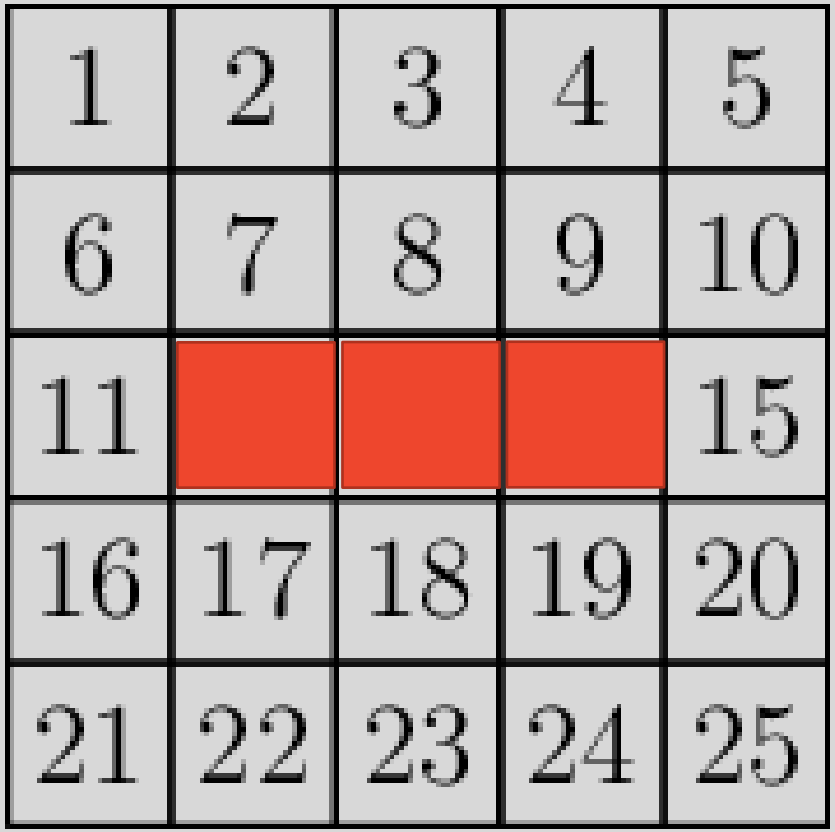


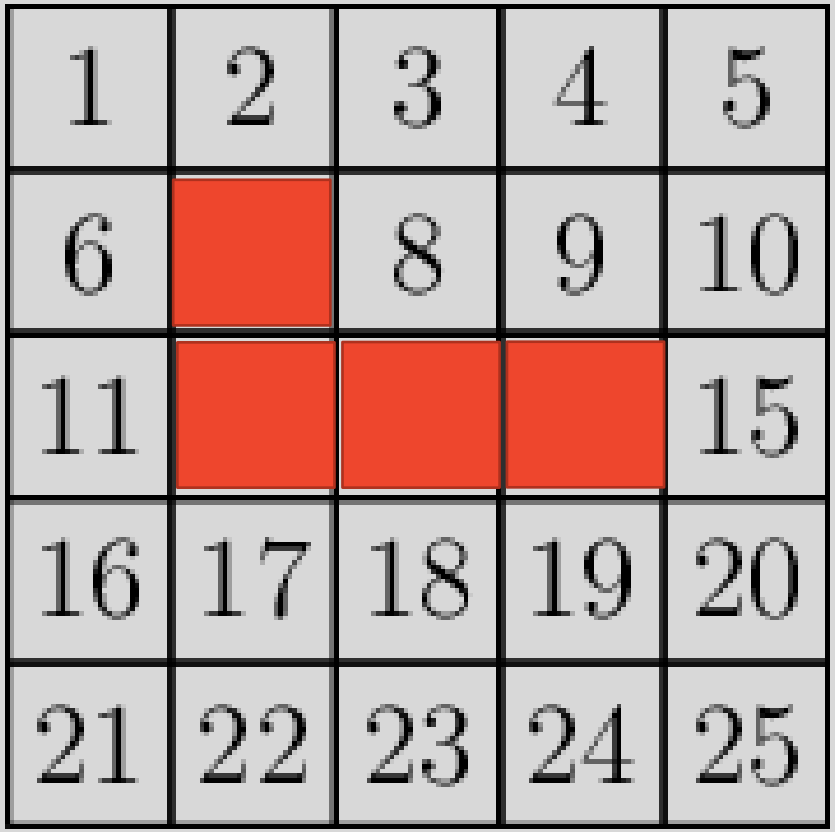
BLINKERS

Let's play the game

Rules

- ***Alive***: if 3 neighbours are alive
- ***Stay alive***: if 2 or 3 neighbours are alive
- ***Dead***: otherwise

Time =0

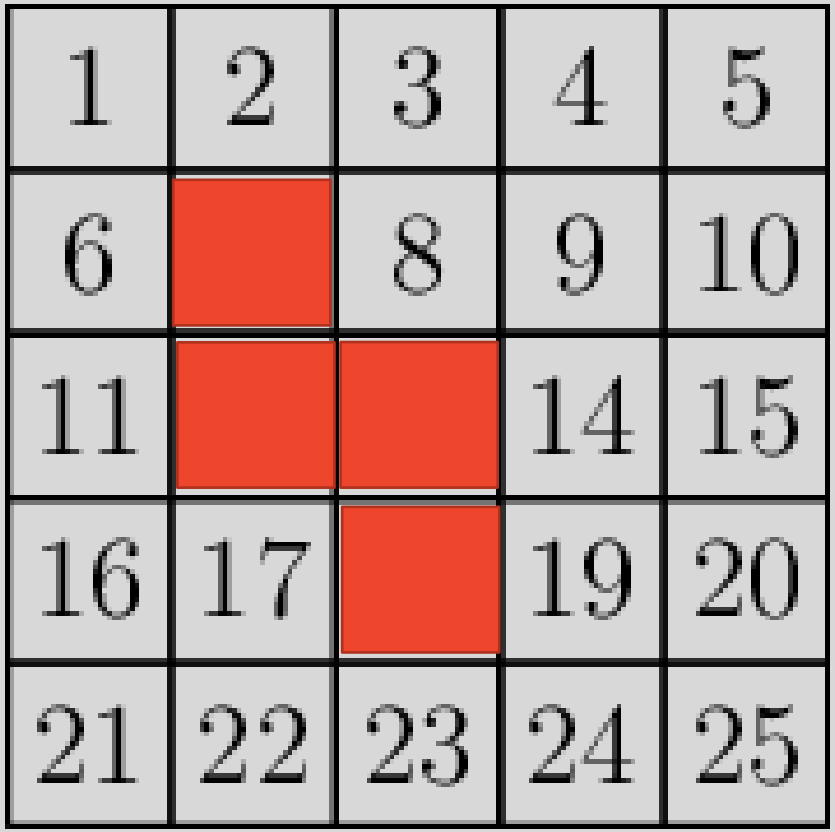


Let's play the game

Rules

- ***Alive***: if 3 neighbours are alive
- ***Stay alive***: if 2 or 3 neighbours are alive
- ***Dead***: otherwise

Time =1



Let's play the game

Rules

- ***Alive***: if 3 neighbours are alive
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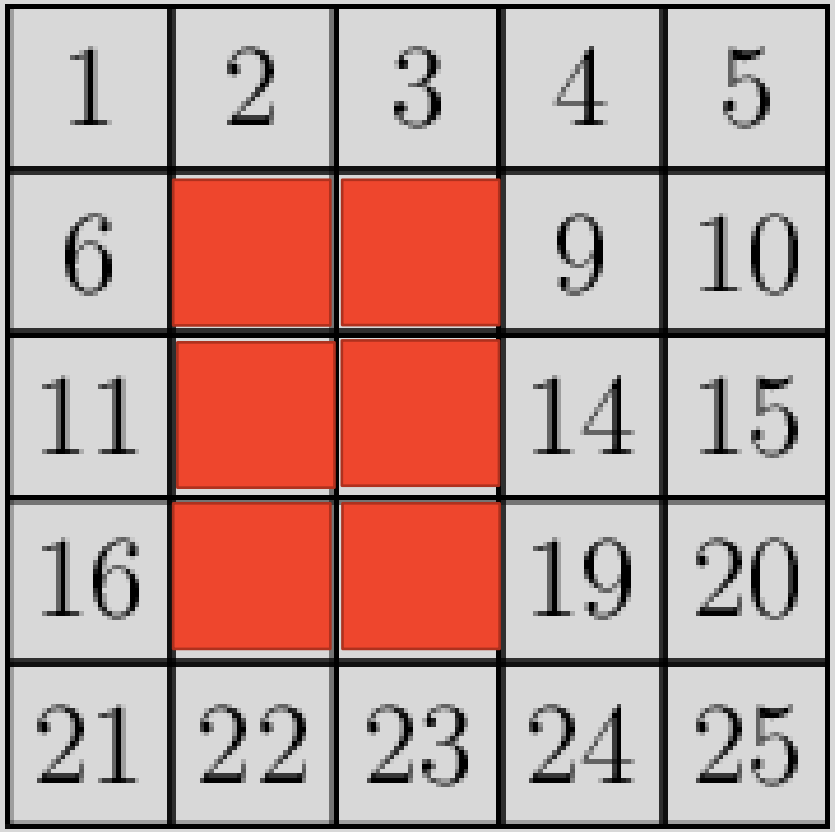
Time =2



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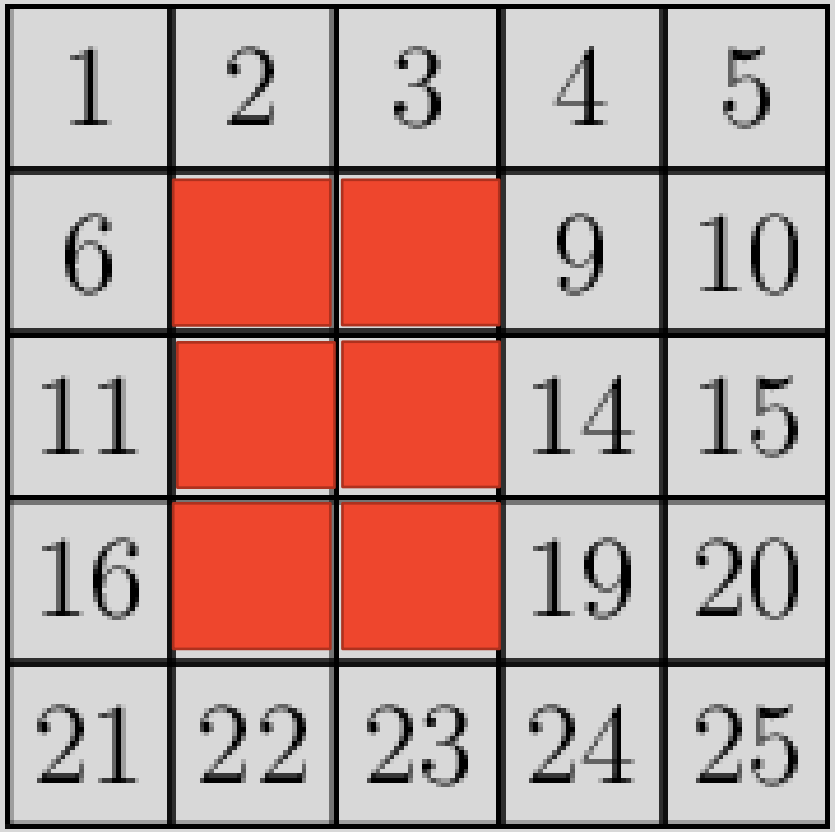
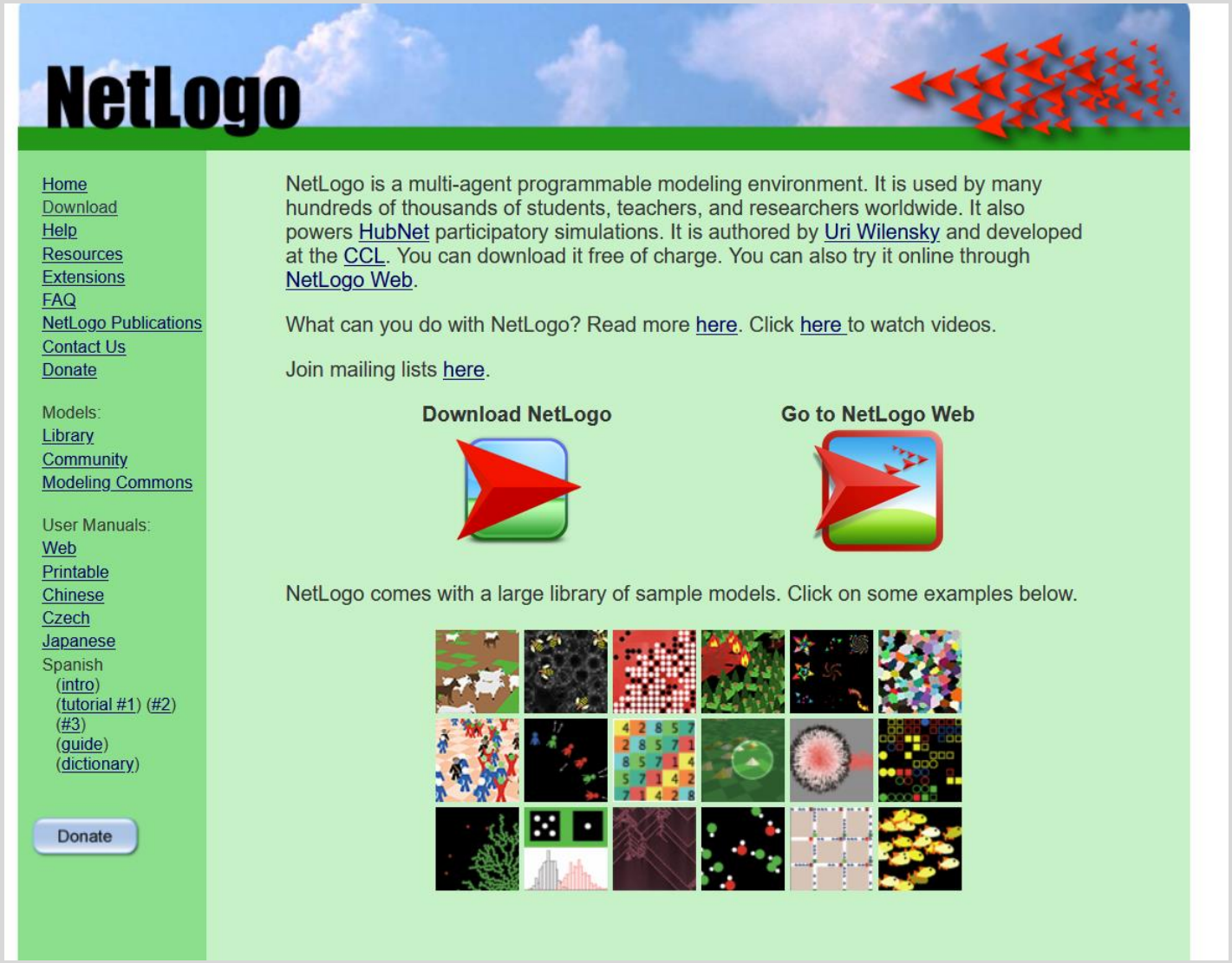
Time =2

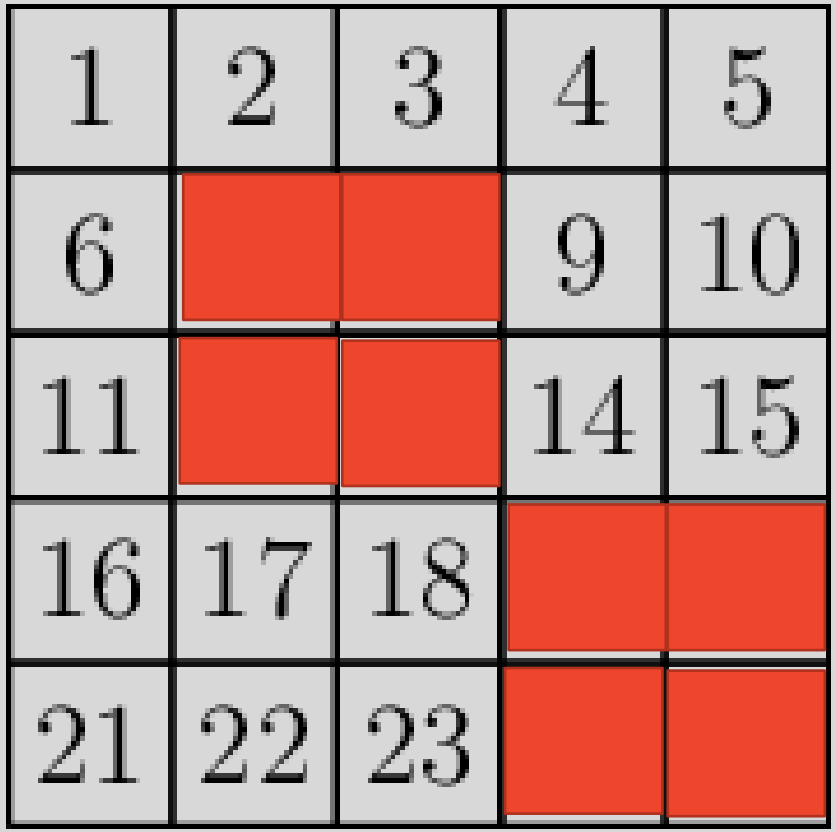


GROWTH

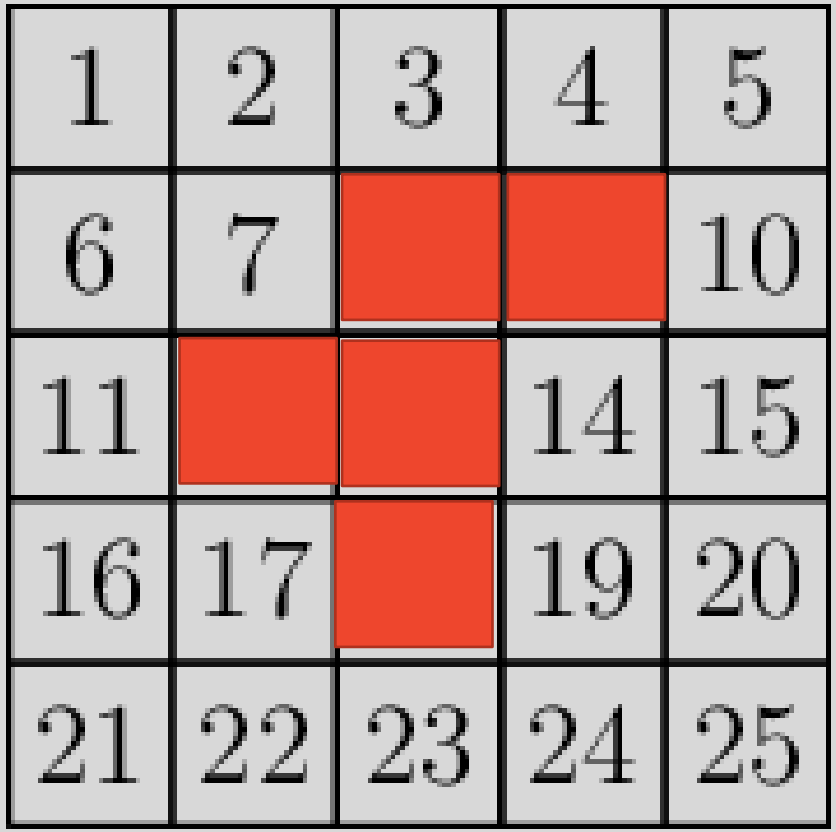


- http://www.netlogoweb.org/launch#http://www.netlogoweb.org/assets/modelslib/IABM%20Textbook/chapter%202/Life%20Simple.nlogo

DIY: Some classic initial conditions



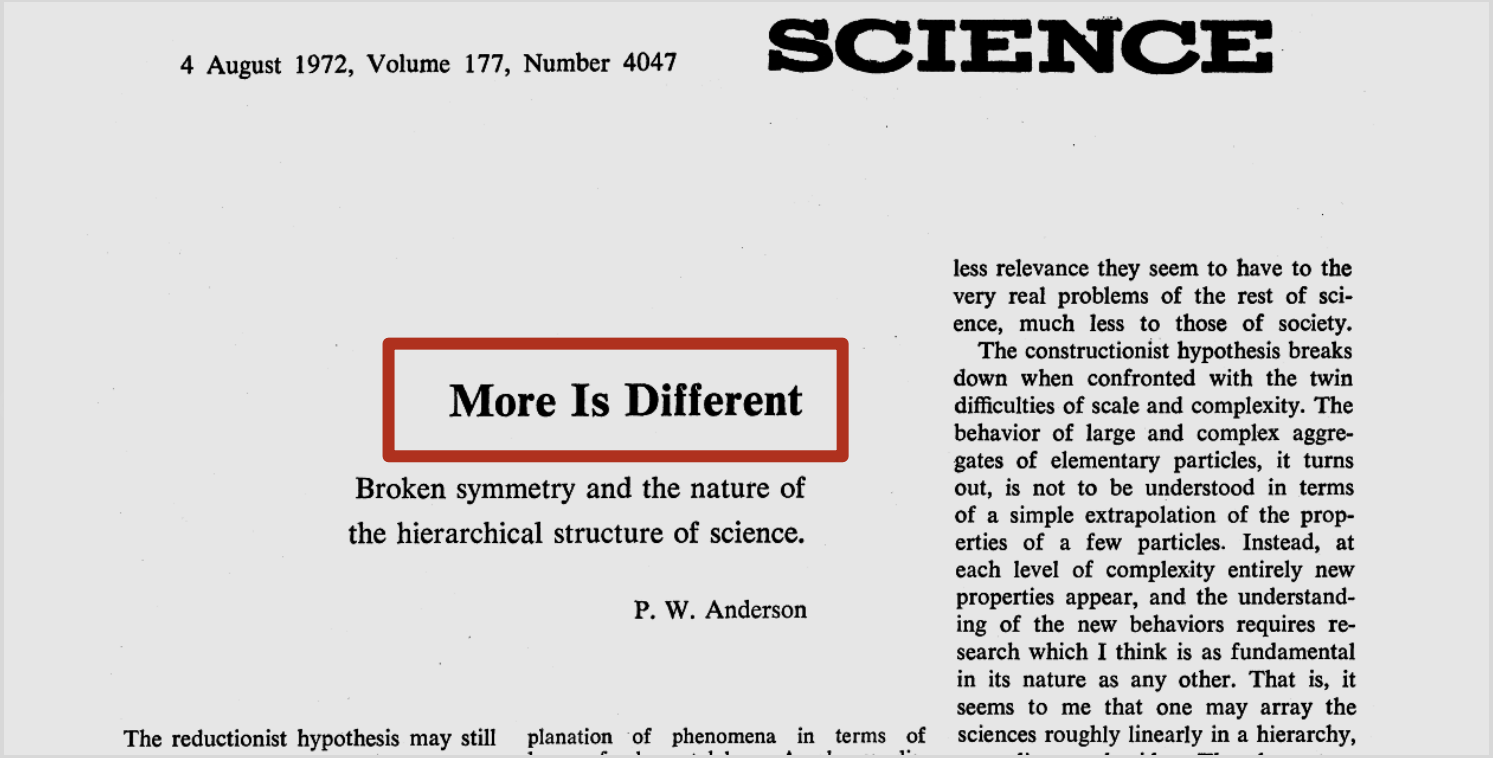
BEACON



F-Pentomino

THE CONWAY'S GAME OF LIFE IS A FAMOUS CELLULAR AUTOMATA

Take home messages

1. Simple model → Complex pattern
2. 

4 August 1972, Volume 177, Number 4047

SCIENCE

More Is Different

Broken symmetry and the nature of the hierarchical structure of science.

P. W. Anderson

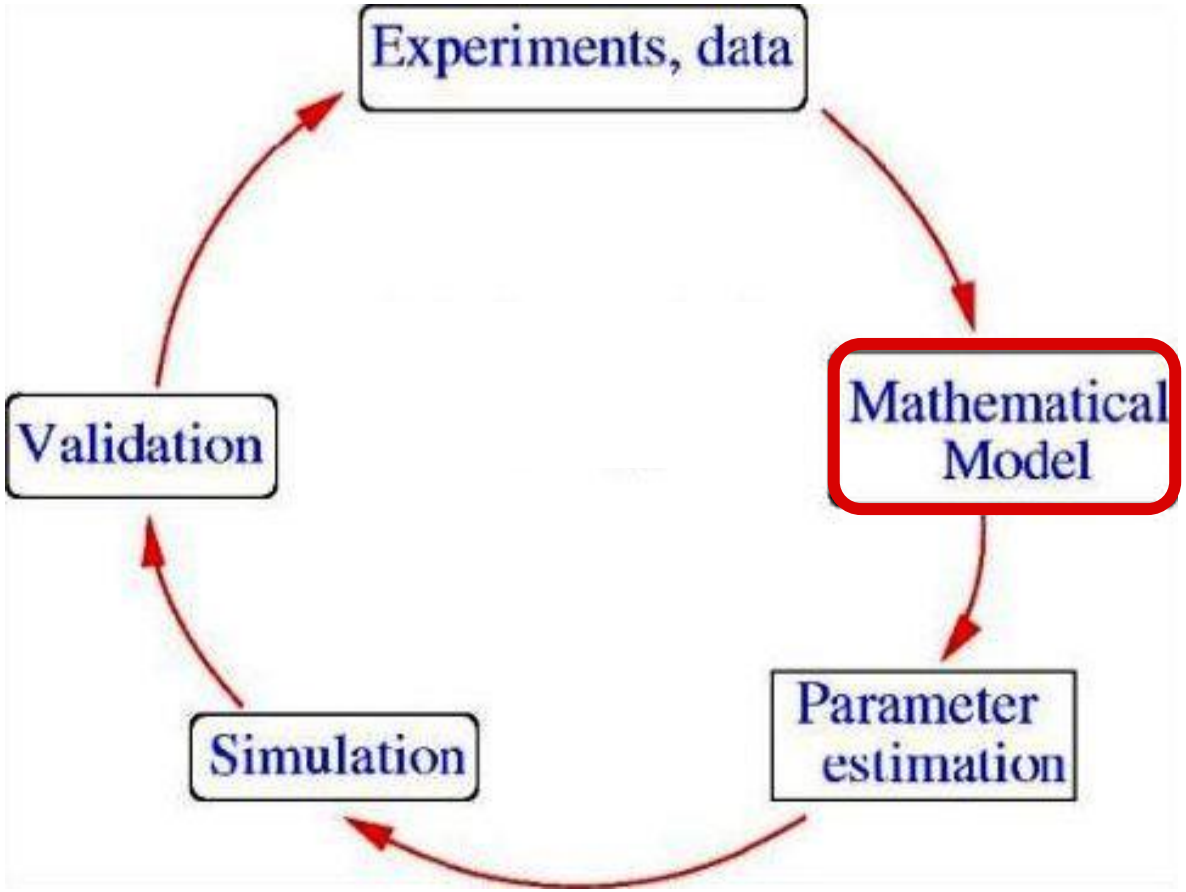
The reductionist hypothesis may still ... planation of phenomena in terms of ...

less relevance they seem to have to the very real problems of the rest of science, much less to those of society.

The constructionist hypothesis breaks down when confronted with the twin difficulties of scale and complexity. The behavior of large and complex aggregates of elementary particles, it turns out, is not to be understood in terms of a simple extrapolation of the properties of a few particles. Instead, at each level of complexity entirely new properties appear, and the understanding of the new behaviors requires research which I think is as fundamental in its nature as any other. That is, it seems to me that one may array the sciences roughly linearly in a hierarchy,

Always remember the model assumptions

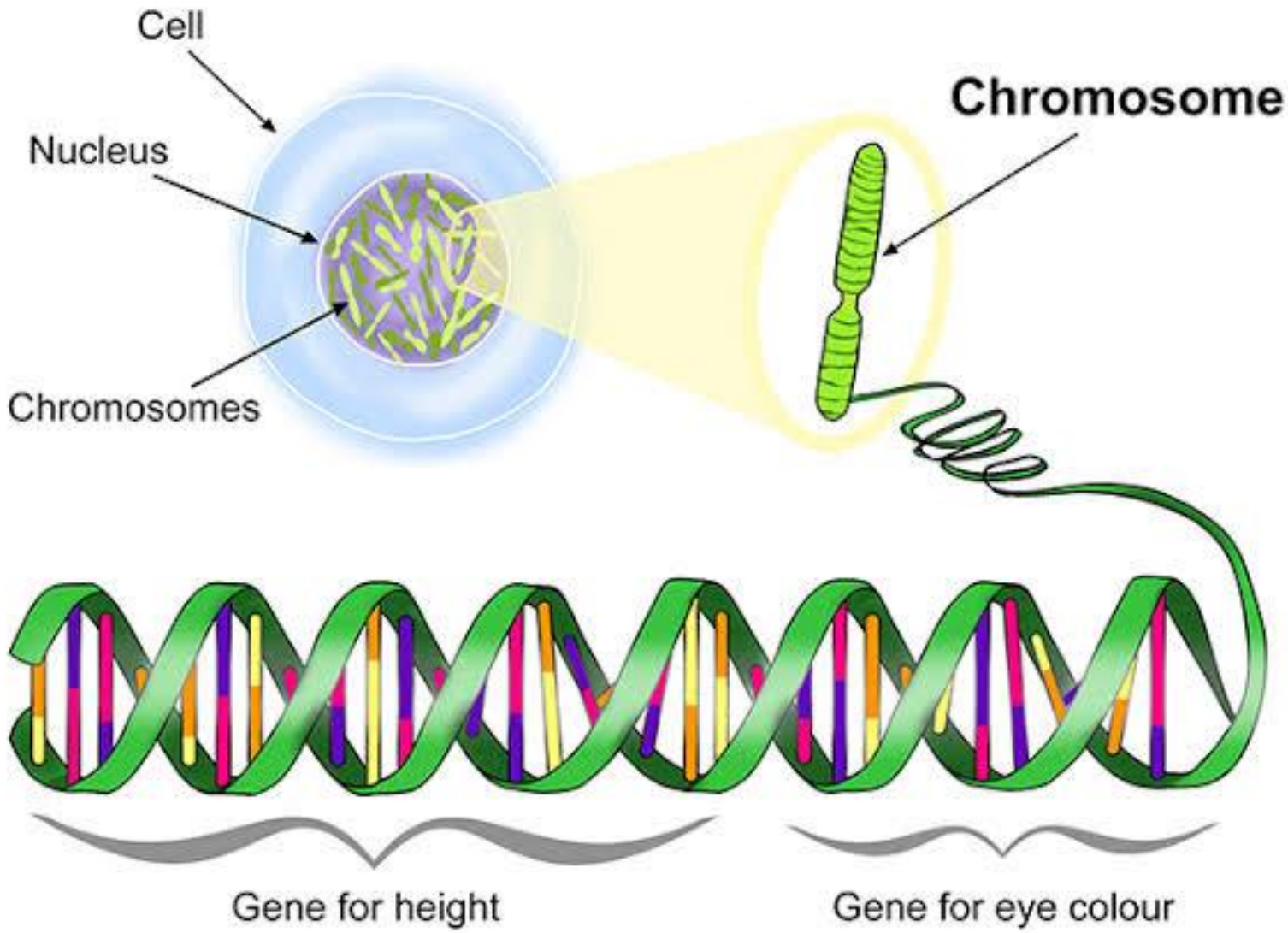
In the greater scheme of things



Computational /mathematical models complement experiments, and vice versa.

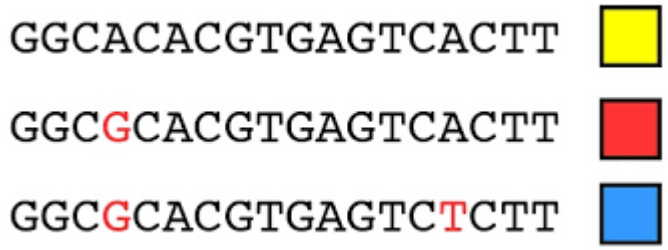
Any questions?

DNA, genes and alleles


Cell
Nucleus
Chromosomes
Chromosome
Gene for height
Gene for eye colour

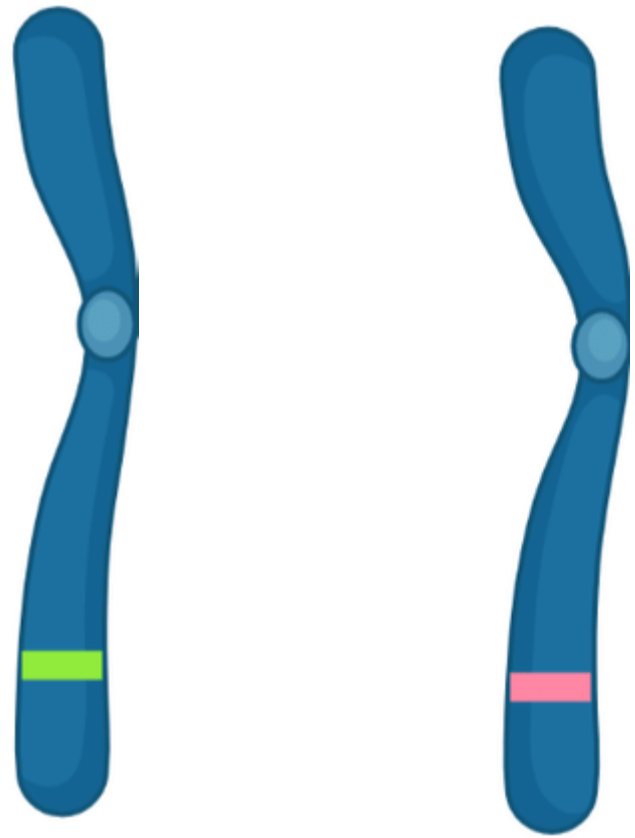
Gene → Portion of DNA sequence that codes for a protein

Alleles → Versions of a gene

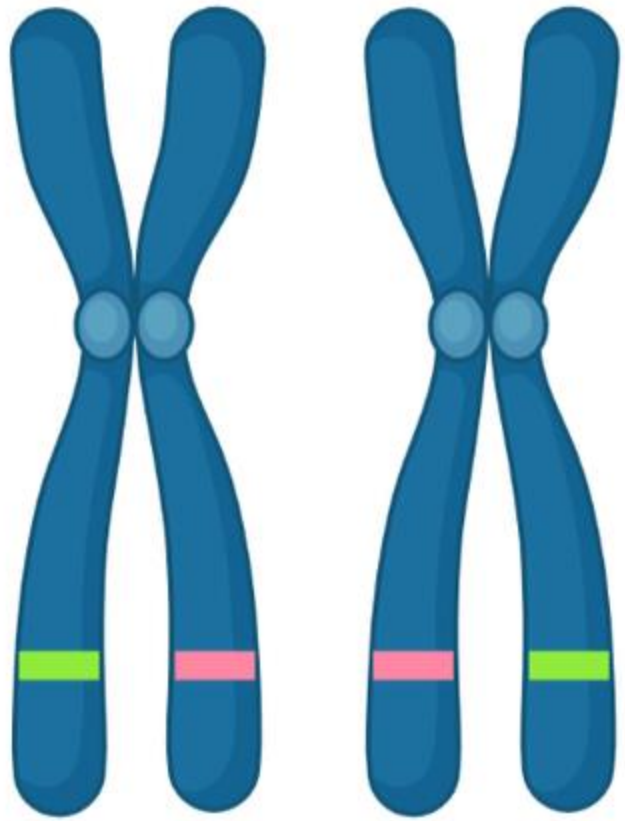


Genotype→ Representation of an individual in terms of alleles

Phenotype→ Representation of an individual in terms of observable traits

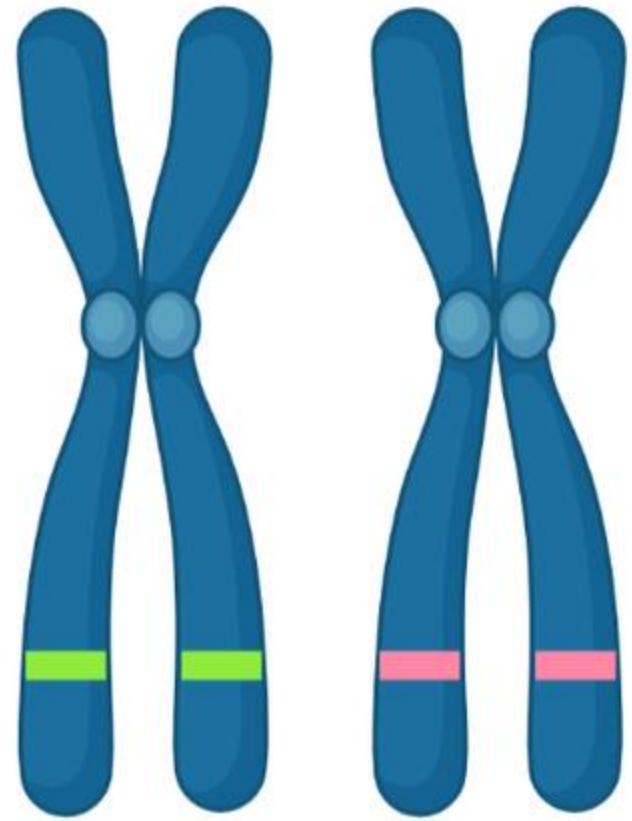


heterozygous



Aa aA

homozygous



AA aa