NetBioDyn, an easy to use multi-agents engine for ecosystems simulation

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Road map

□ Multi-Agents Systems (MAS)

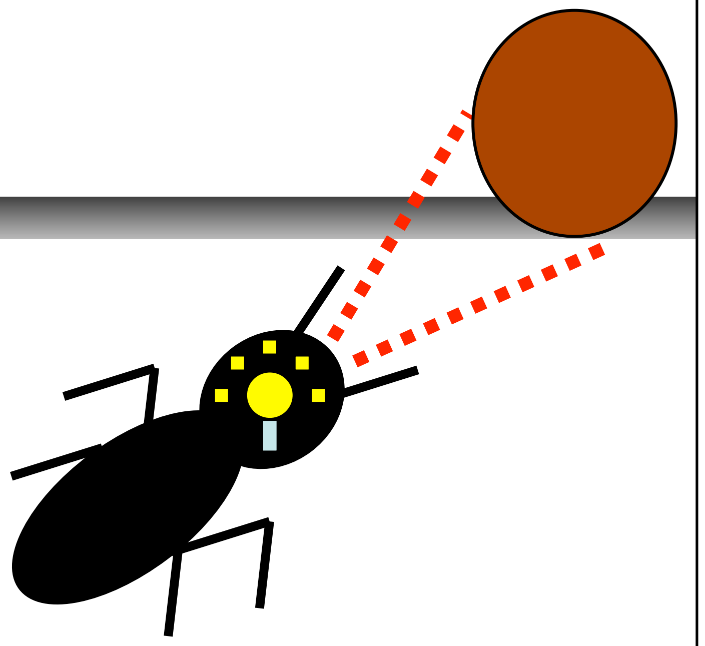
□ From Biological environment simulation

□ Towards Ecosystems simulation

□ NetBioDyn software

□ Conclusions and futur works

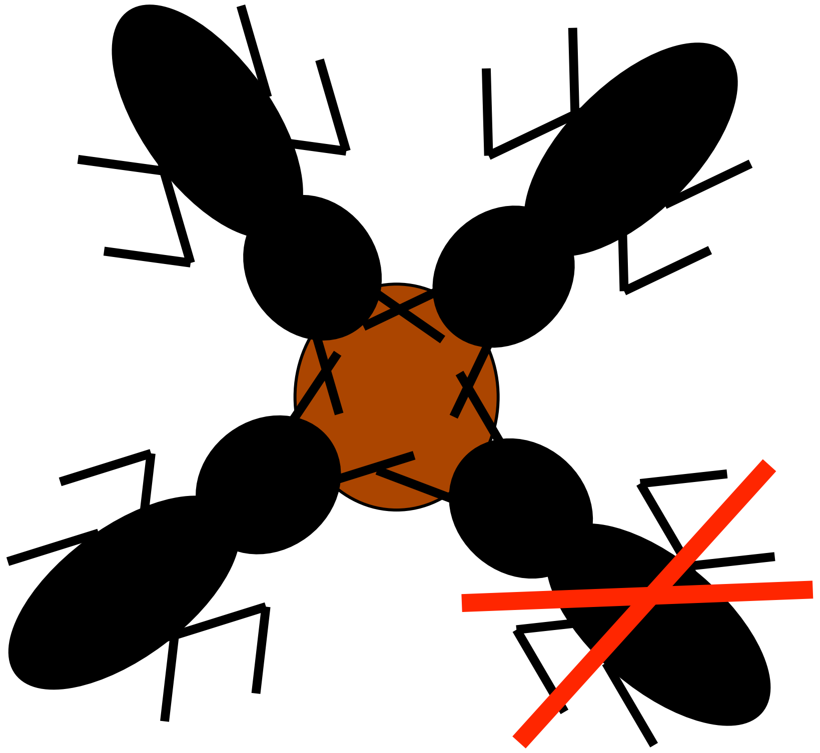
Multi-Agents systems properties



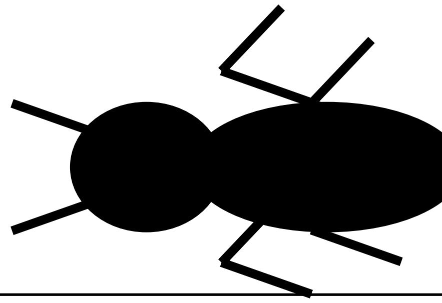
Agent : perception-decision-action

Multi-agents System :

- **auto-organisation**
- **emergence**
- **robustness**
- **adaptability**



Models' autonomy



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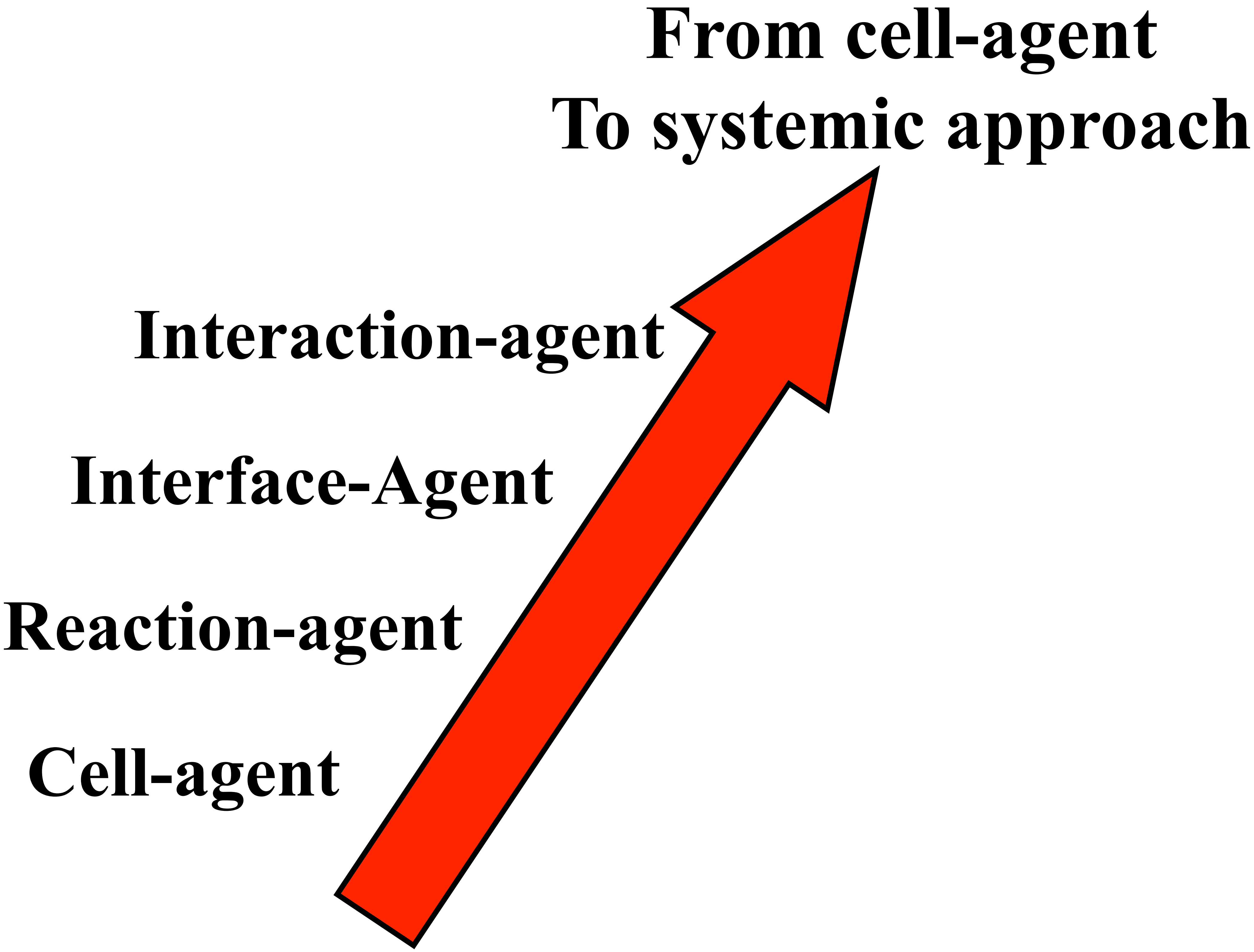
Multi-Agent Systems and Biological modelling & simulation



From cell-agent
To systemic approach

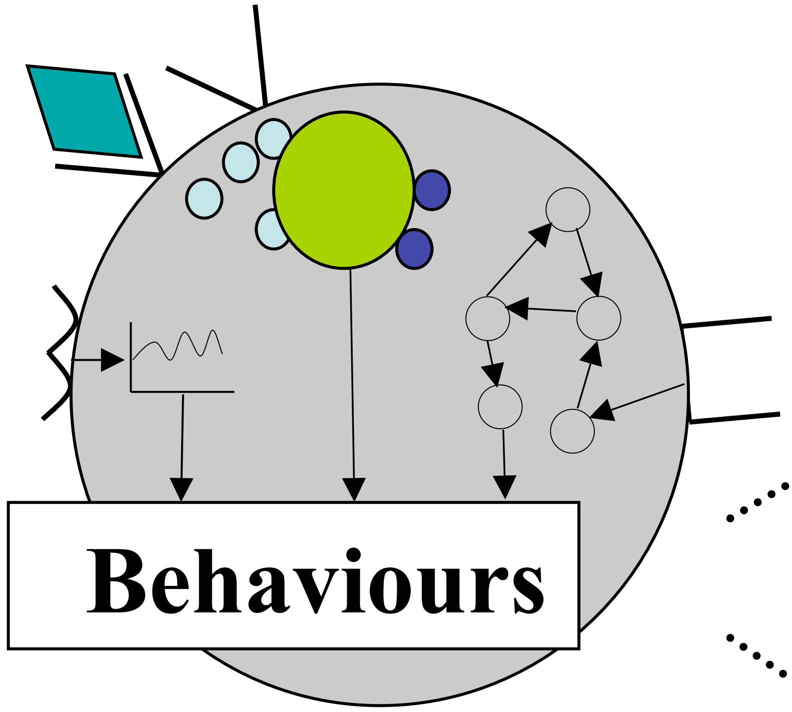
Interaction-agent

Interface-Agent

Reaction-agent

Cell-agent

Cell-agent model



Basic behaviours

- •Mitosis
- •Activation
- •Internalisation
- •Expression of receptor
- •Apoptose

Model of located agents with complex behaviors

Cell-agent model:
An exemple of application

Simulation of physiologic coagulation:

Cell

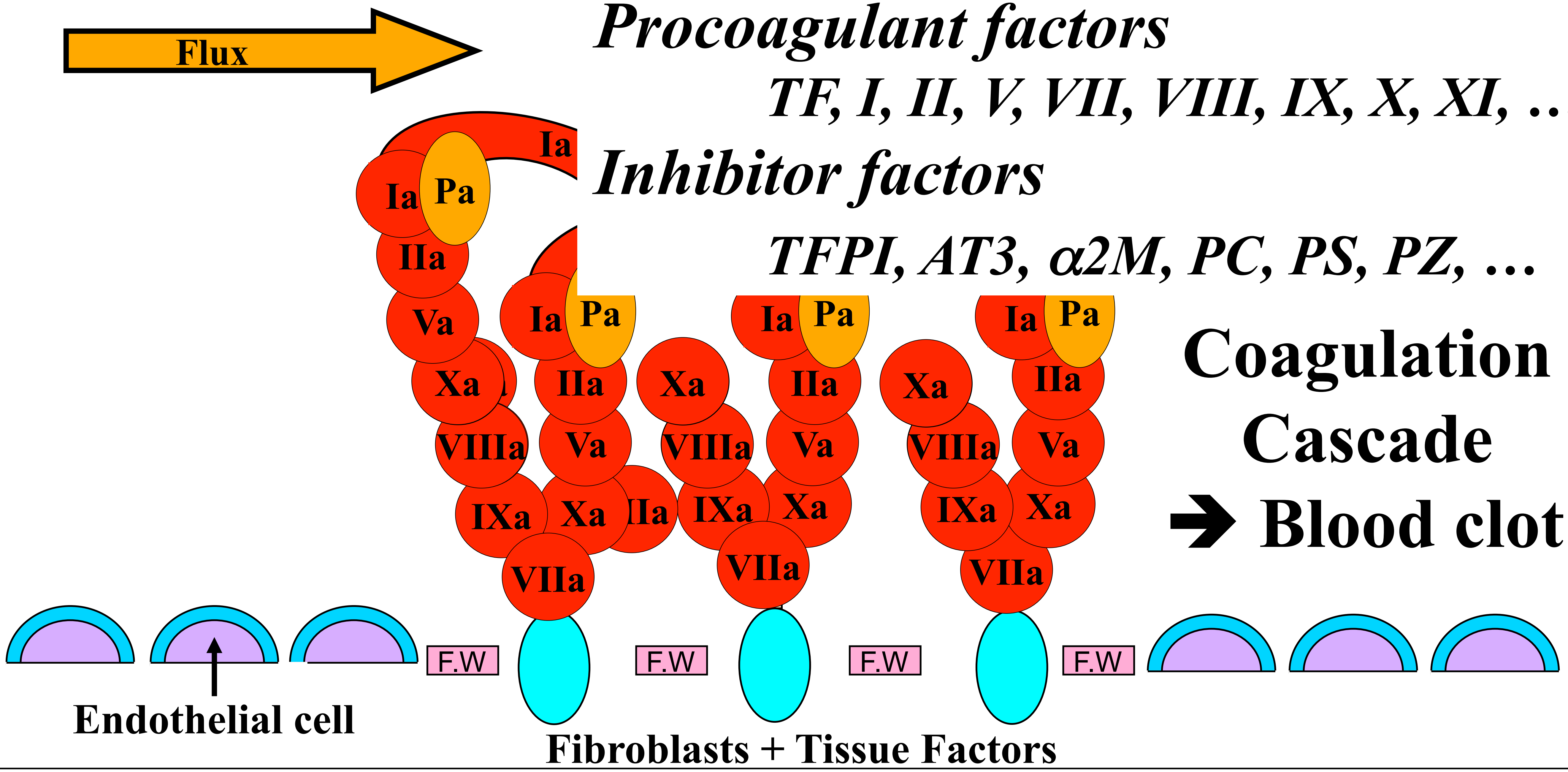
Fibroblasts cells, endothelial cells, platelet

Procoagulant factors

TF, I, II, V, VII, VIII, IX, X, XI, …

Inhibitor factors

TFPI, AT3, α2M, PC, PS, PZ, …

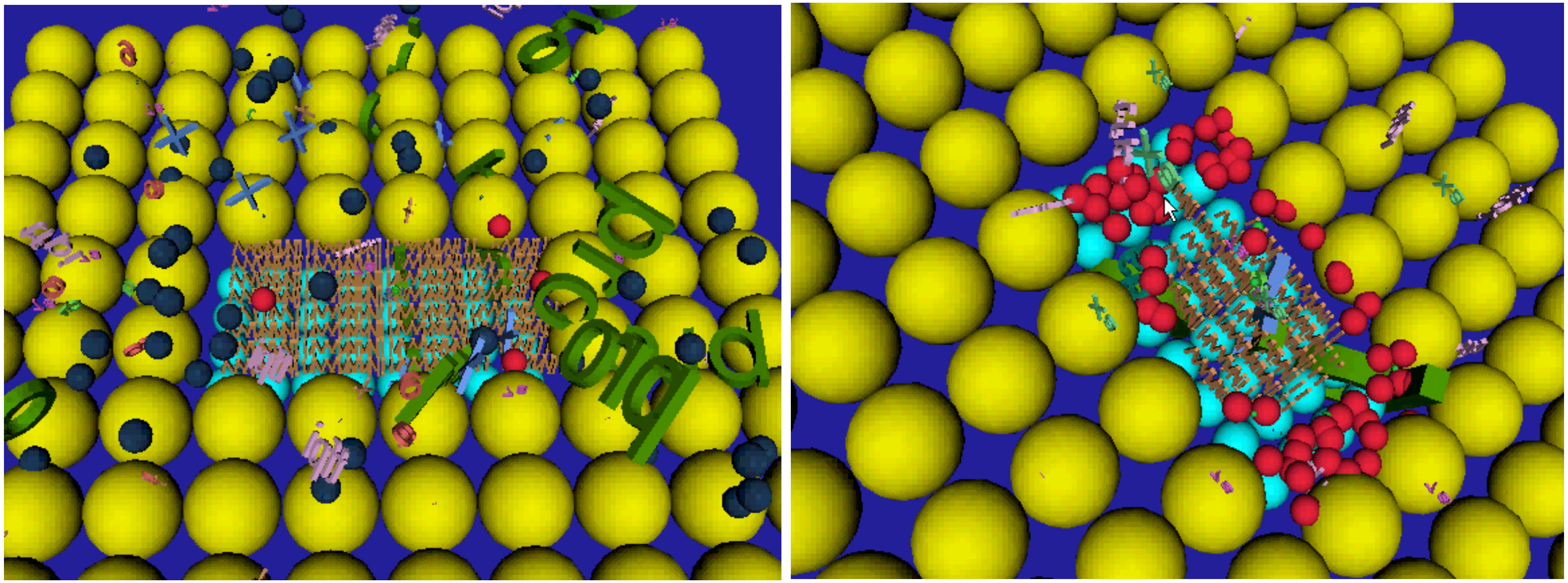


Coagulation Cascade

➔ Blood clot

Cell-agent model: An exemple of application

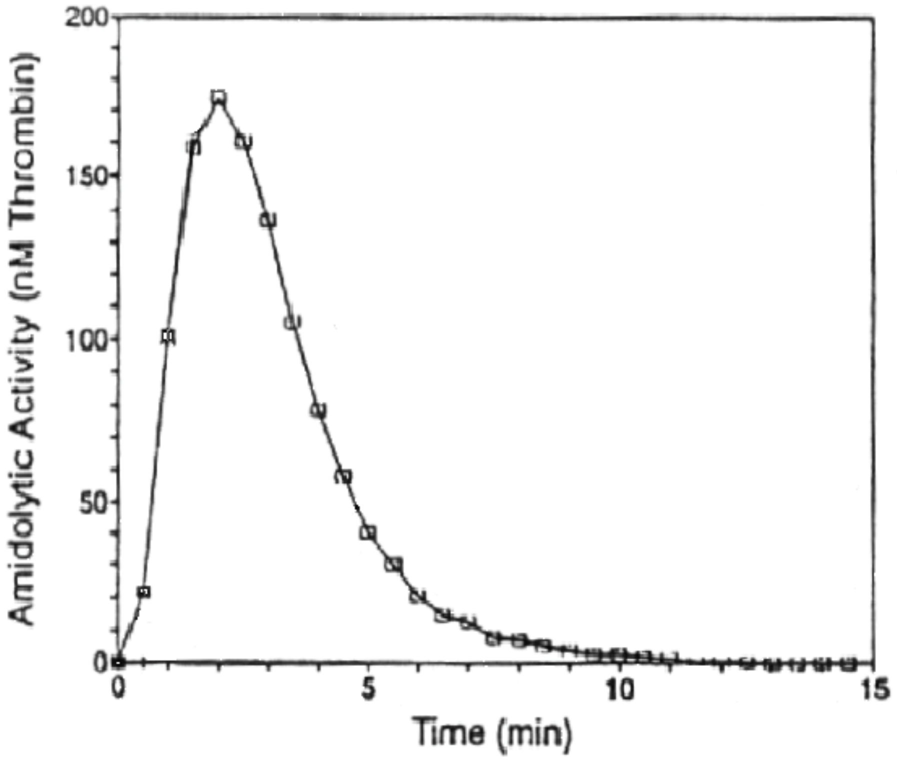
Simulation of physiologic coagulation: ➔ blood clot…



Cell-agent model:
An exemple of application

Elements of validation of the coagulation multiagents model :

- Comparison with Biological experiment



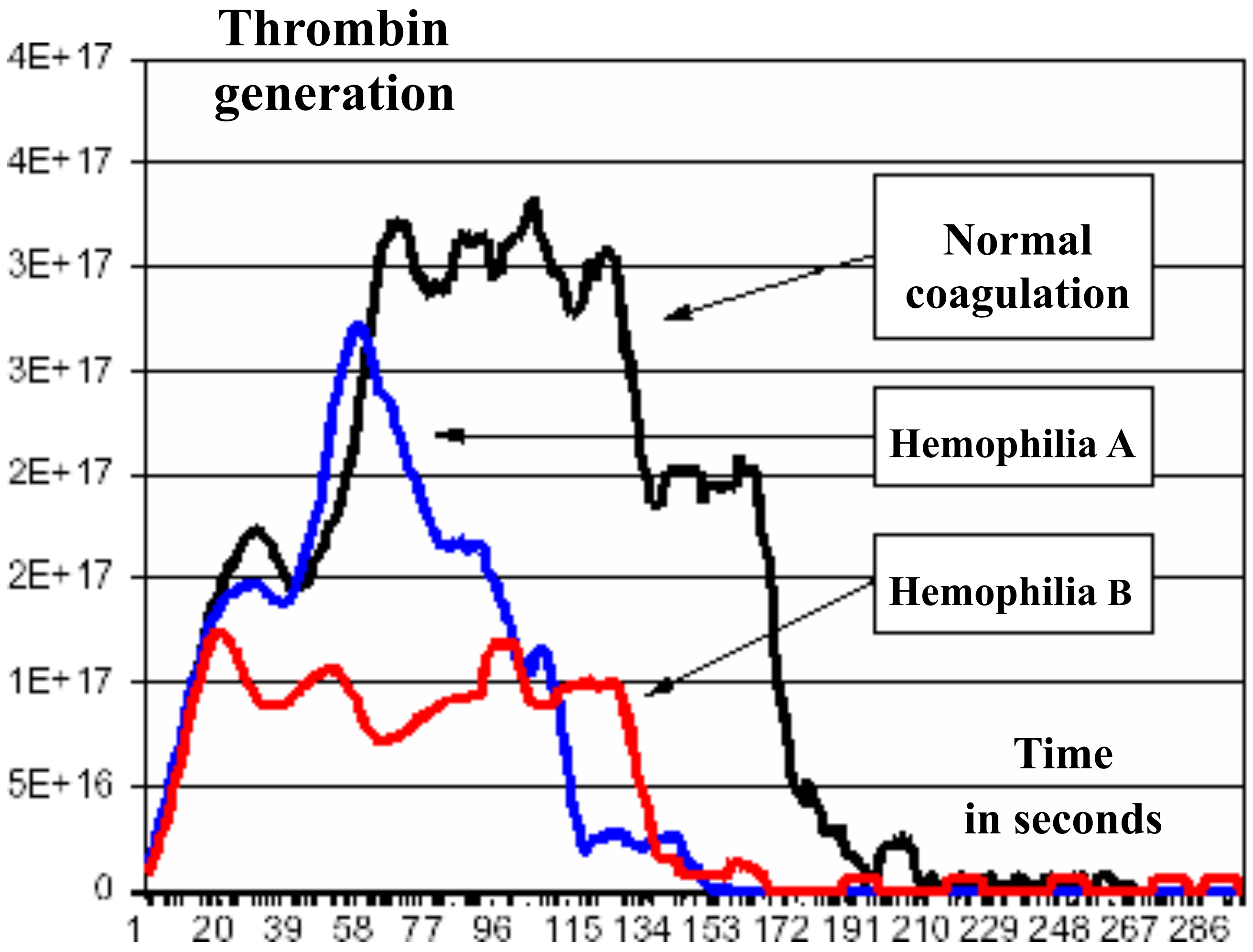
Curve of thrombin Generation [Hemker, 1995]

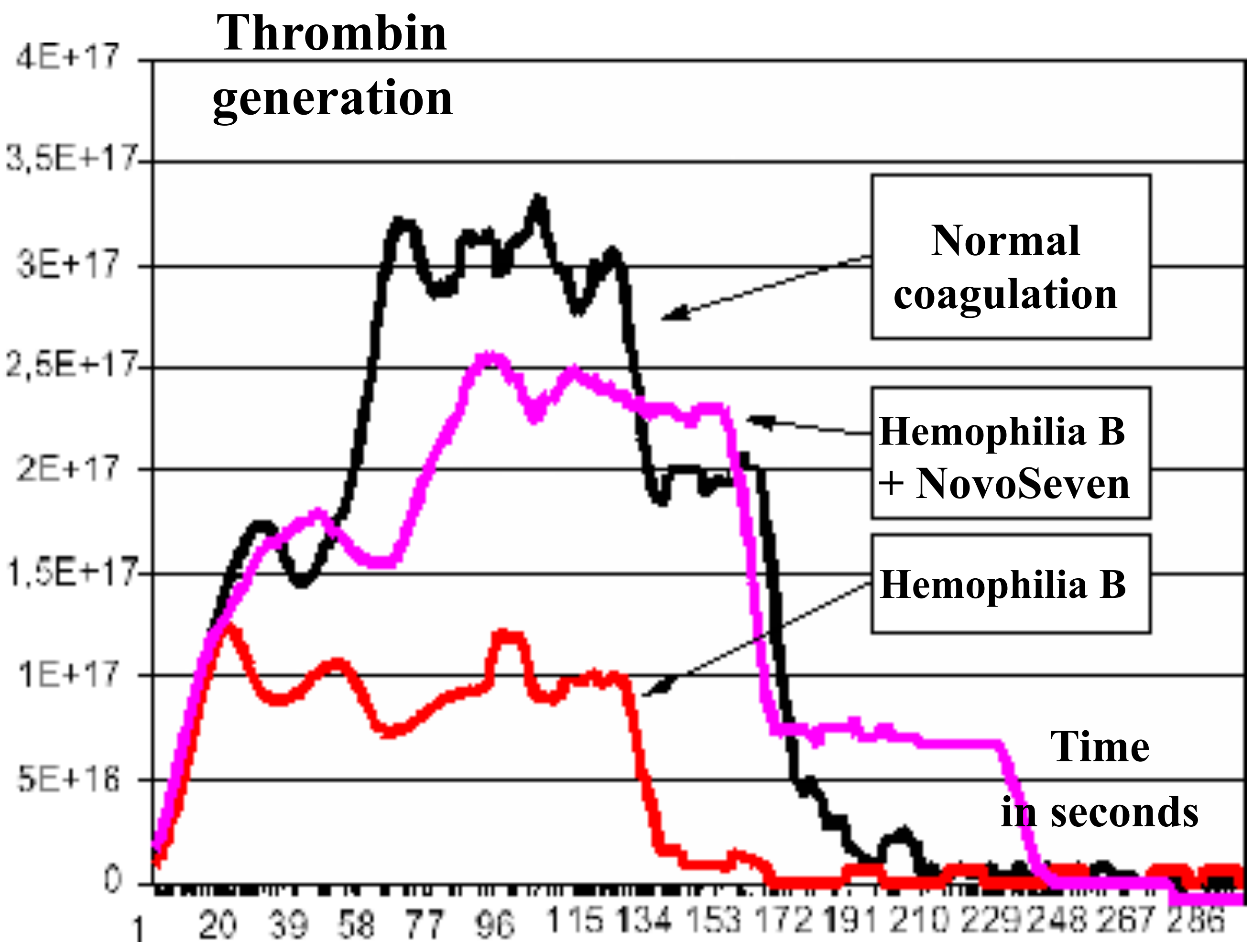
- Coherence with respect to pathologies

Cell-agent model: An exemple of application

Simulation of physiologic coagulation:

Healthy patient, hemophiliac, hemophiliac with treatment





Multi-Agent Systems and Biological modelling & simulation

Vincent Rodin CanTho, 19-22 december 2016

From cell-agent
To systemic approach

Interaction-agent

Interface-Agent

Reaction-agent

Cell-agent

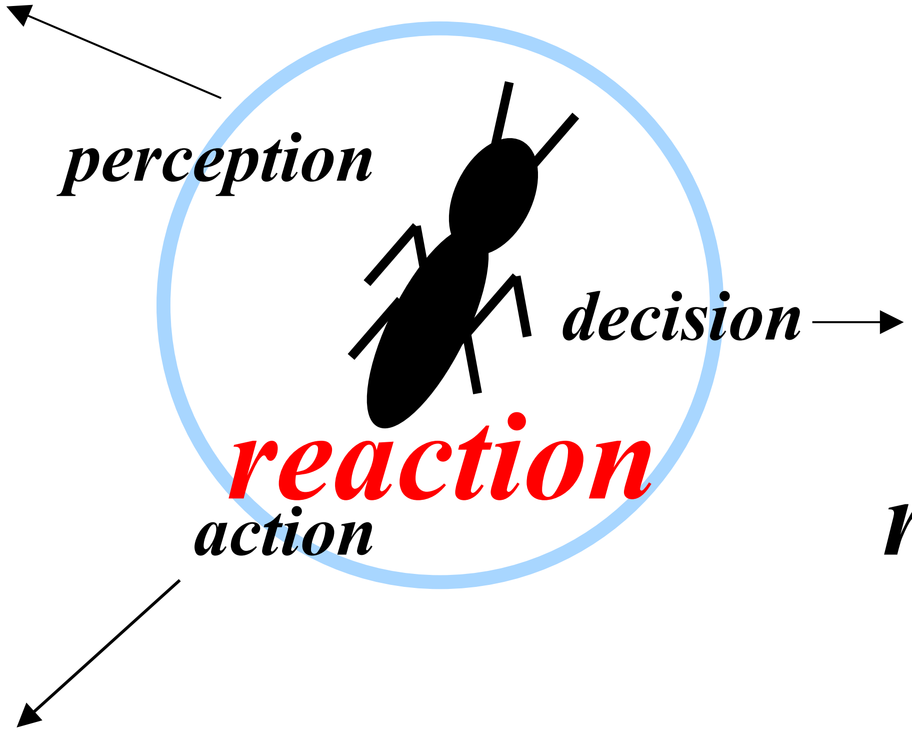
located agent

Reaction-agent model

❑ « microscopic » level : *agent = cell/molecule*

❑ « macroscopic » level : *agent = reaction*

1: reading of the concentrations in reactants



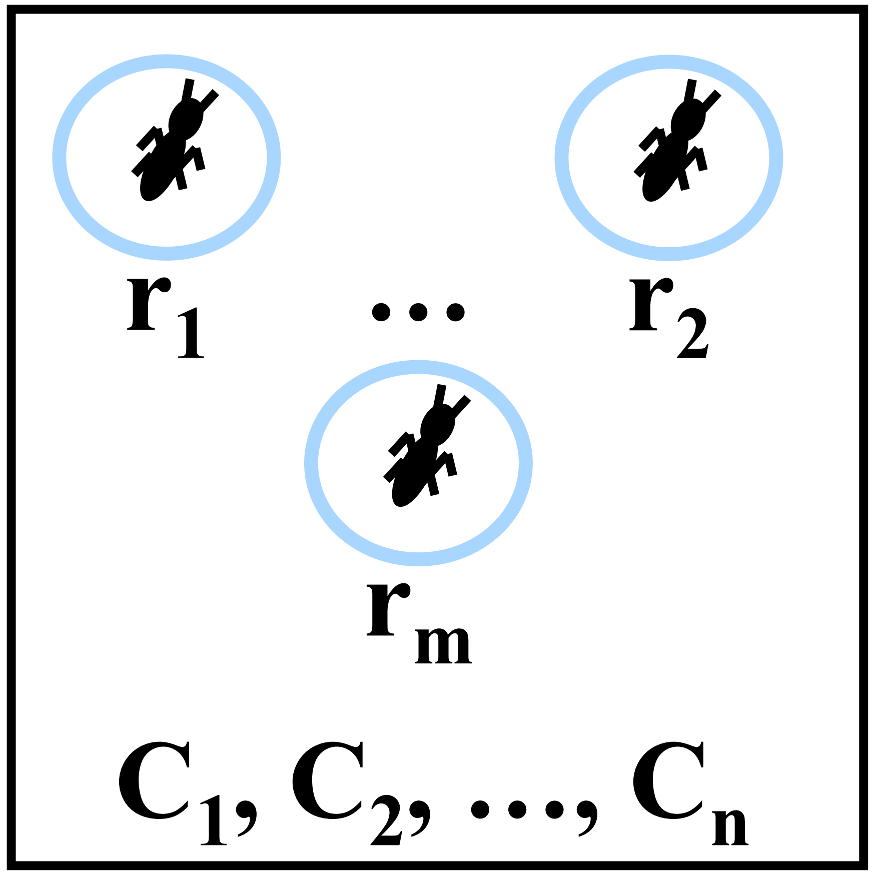
2:calculation the reaction speed and then the quantity of reactant to be reacted

3: consequently, modification of the concentrations in reactants and products

Reaction-agent model

Spatial indiscernibility

Non located agents



Chemical reactor

- ➢ Asynchronous phenomena and chaotic order
- ➢ No Ordinary Differential Equation

Reaction-agent model:
An exemple of application

Simulation of physiologic coagulation:

Healthy patient, hemophiliac, hemophiliac with treatment

Fibroblaste + VIIa -> VII-TF

VII + VIIa -> VIIa + VIIa

VII + VII-TF -> VIIa + VII-TF

IX + VII-TF -> IXa + VII-TF

X + VII-TF -> Xa + VII-TF

TFPI + Xa -> TFPI-Xa

TFPI-Xa + VII-TF -> 0

VIIIa + IXa -> VIIIa-IXa

VIIIa-IXa + X -> VIIIa-IXa + Xa

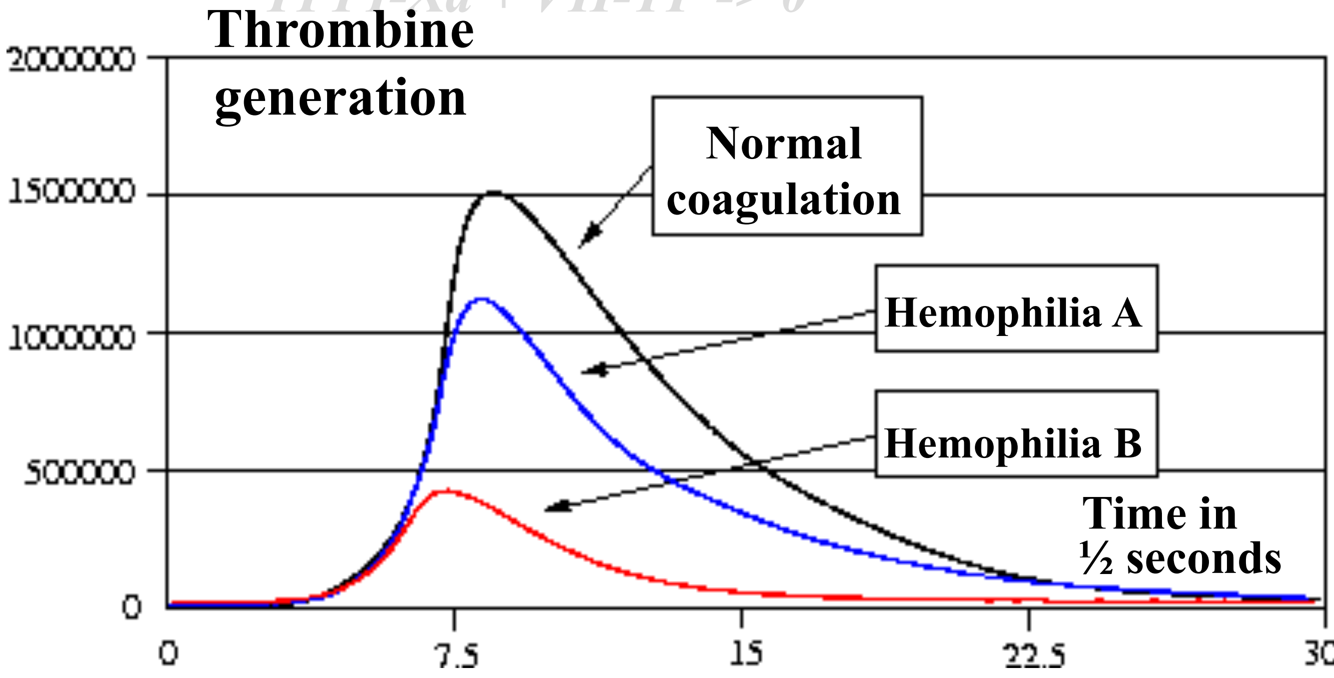
Va-Xa + II -> Va-Xa + IIa

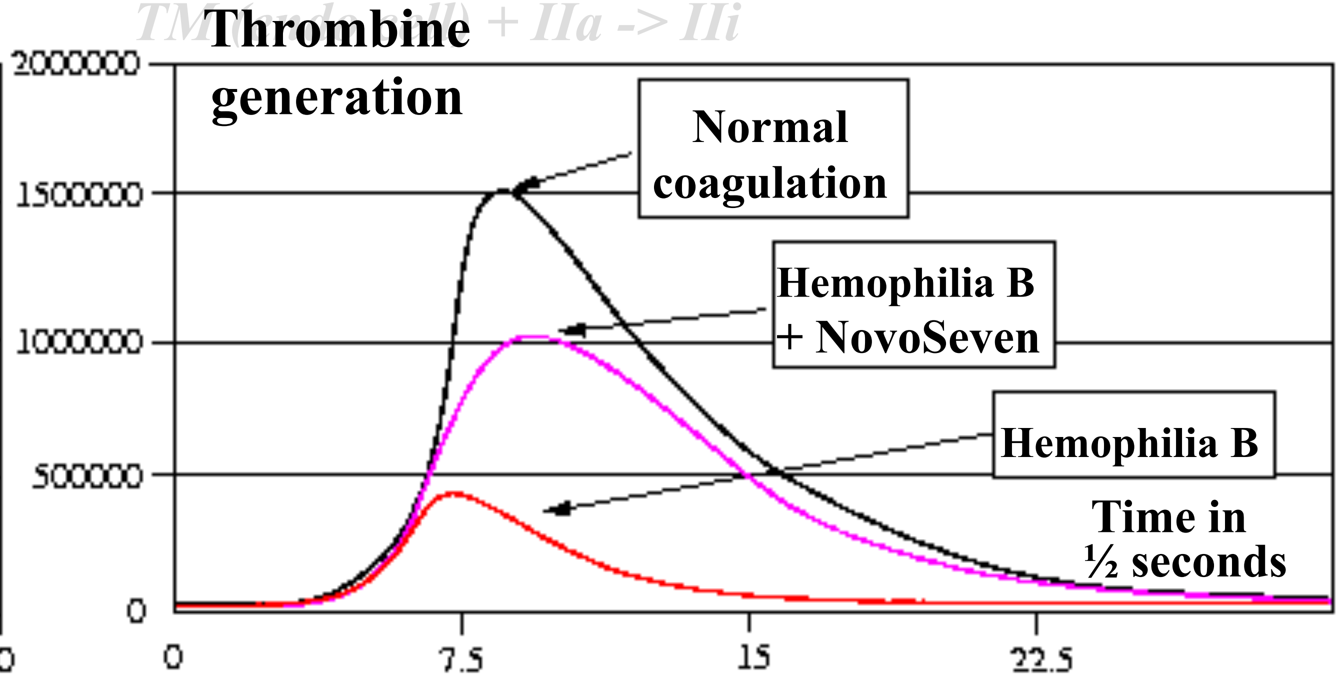
AT3 + (IXa, Xa, XIa, IIa) -> 0

alpha2M + IIa -> 0

I + IIa -> Ia + IIa

TM(endo cell) + IIa -> IIi





IIa + V -> IIa + Va

Xa + V -> Xa + Va

Xa + VIII -> Xa + VIIIa

Xa + Va -> Va-Xa

PCaS + Va -> 0

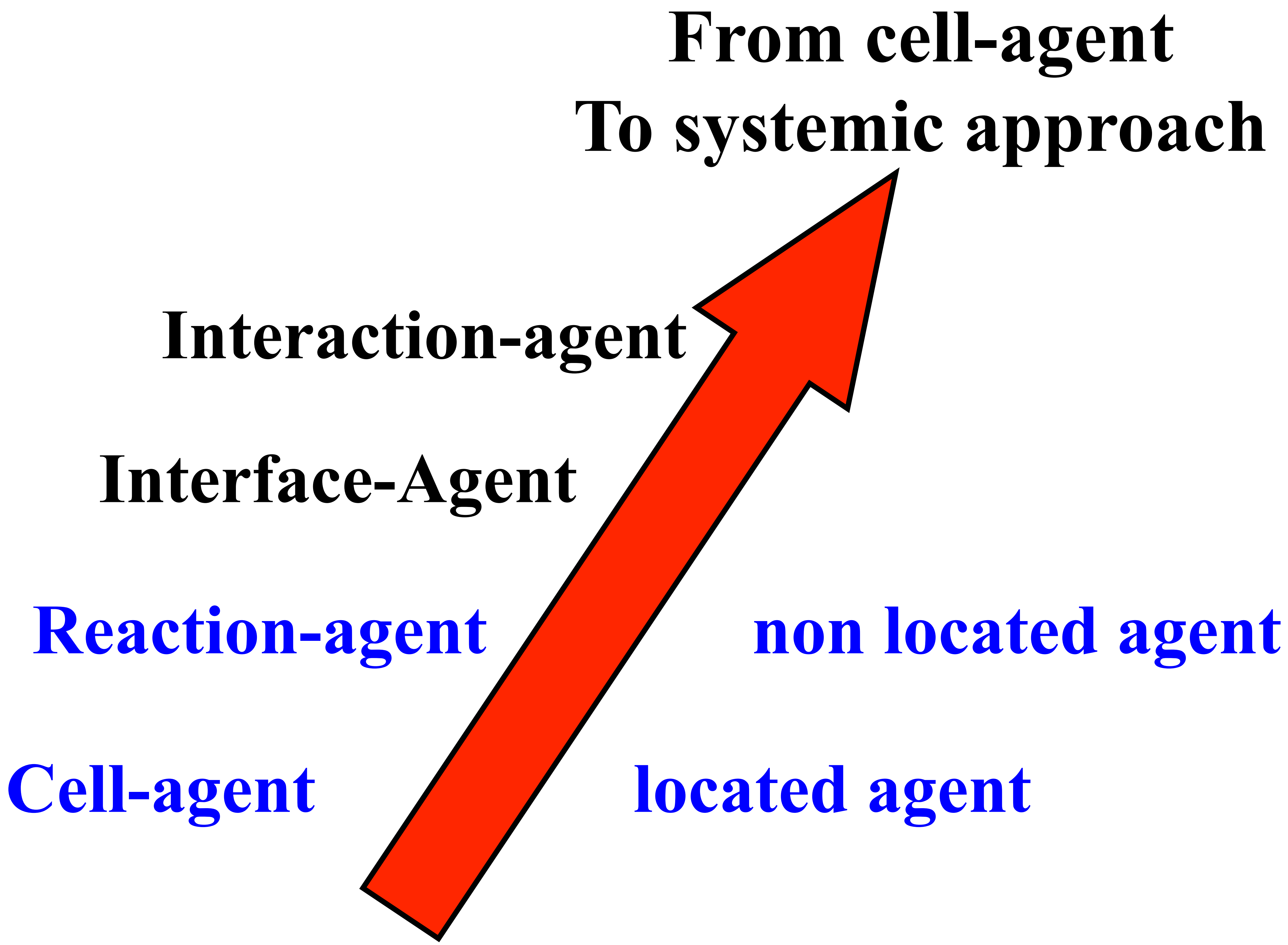
PCaS + V -> PCa-S-V

PCa-S-V + VIIIa-IXa -> IXa

PCa-S-V + VIIIa -> 0

42 reactions

Multi-Agent Systems and Biological modelling & simulation



From cell-agent
To systemic approach

Interaction-agent

Interface-Agent

Reaction-agent

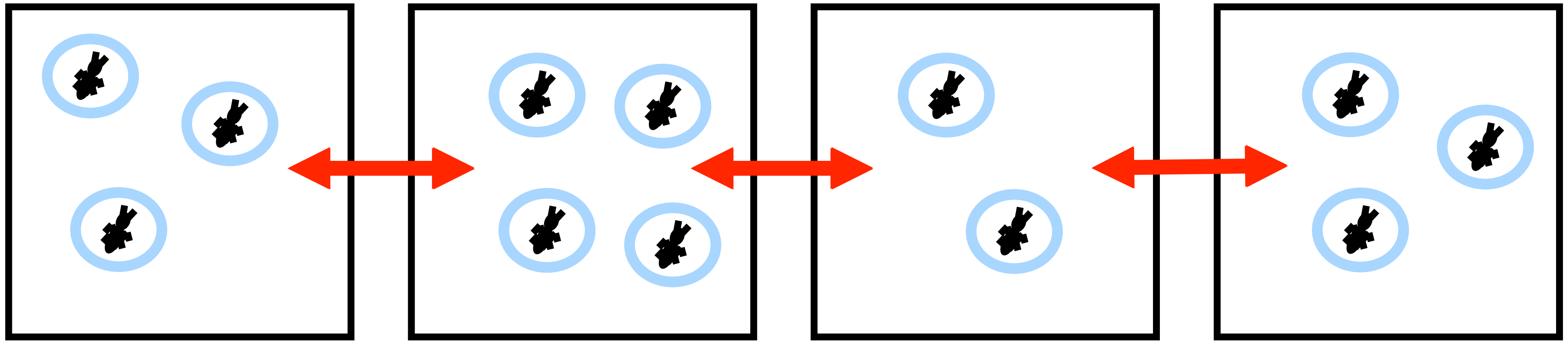
non located agent

Cell-agent

located agent

Interface-agent model

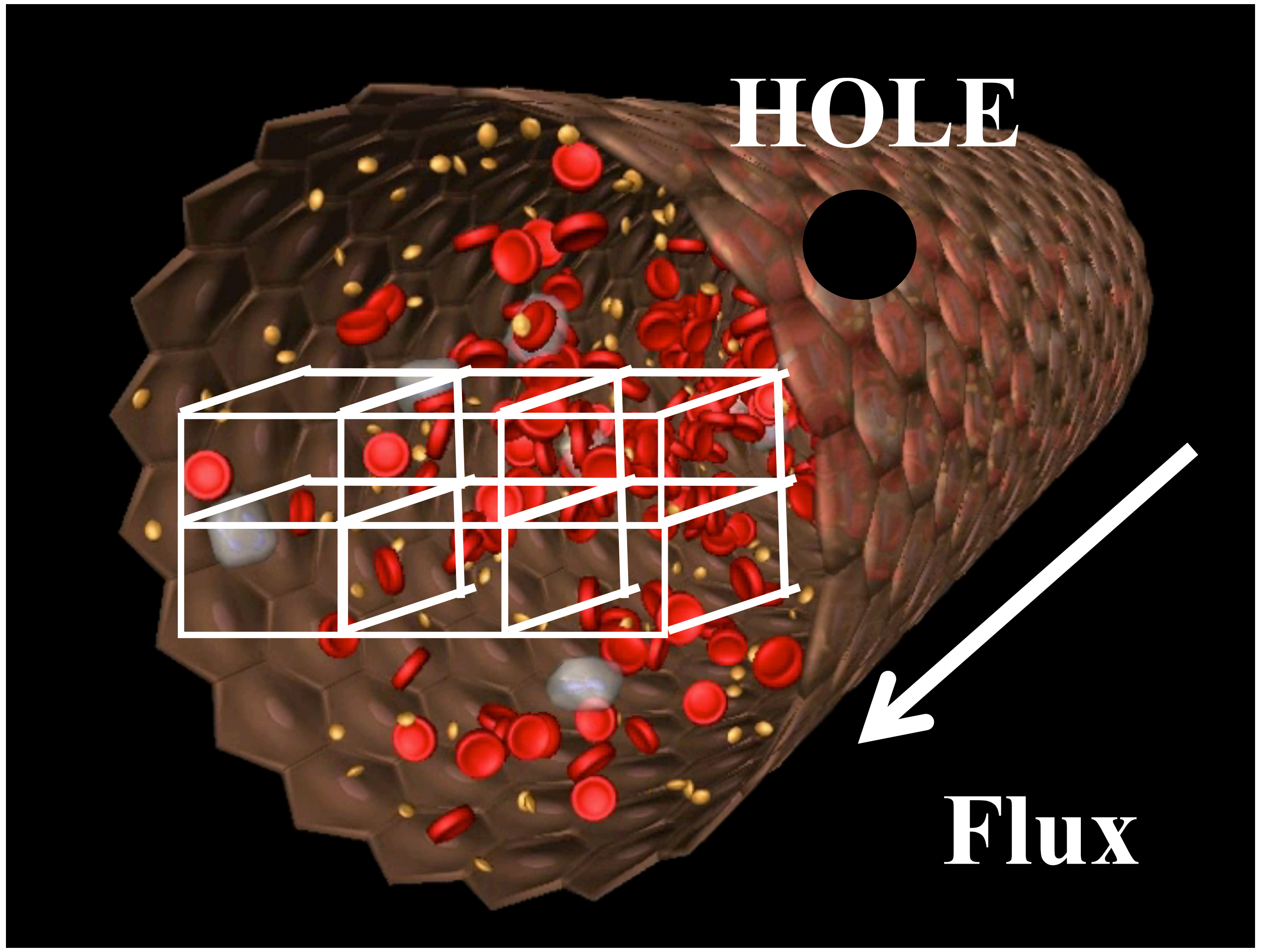
An « agent » point of view:



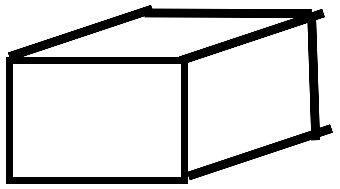
- ➢ Interface-agent
  ➔ <u>interaction</u> between the mediums
- ➢ Asynchronous phenomena and chaotic order
- ➢ No Partial Differential Equation

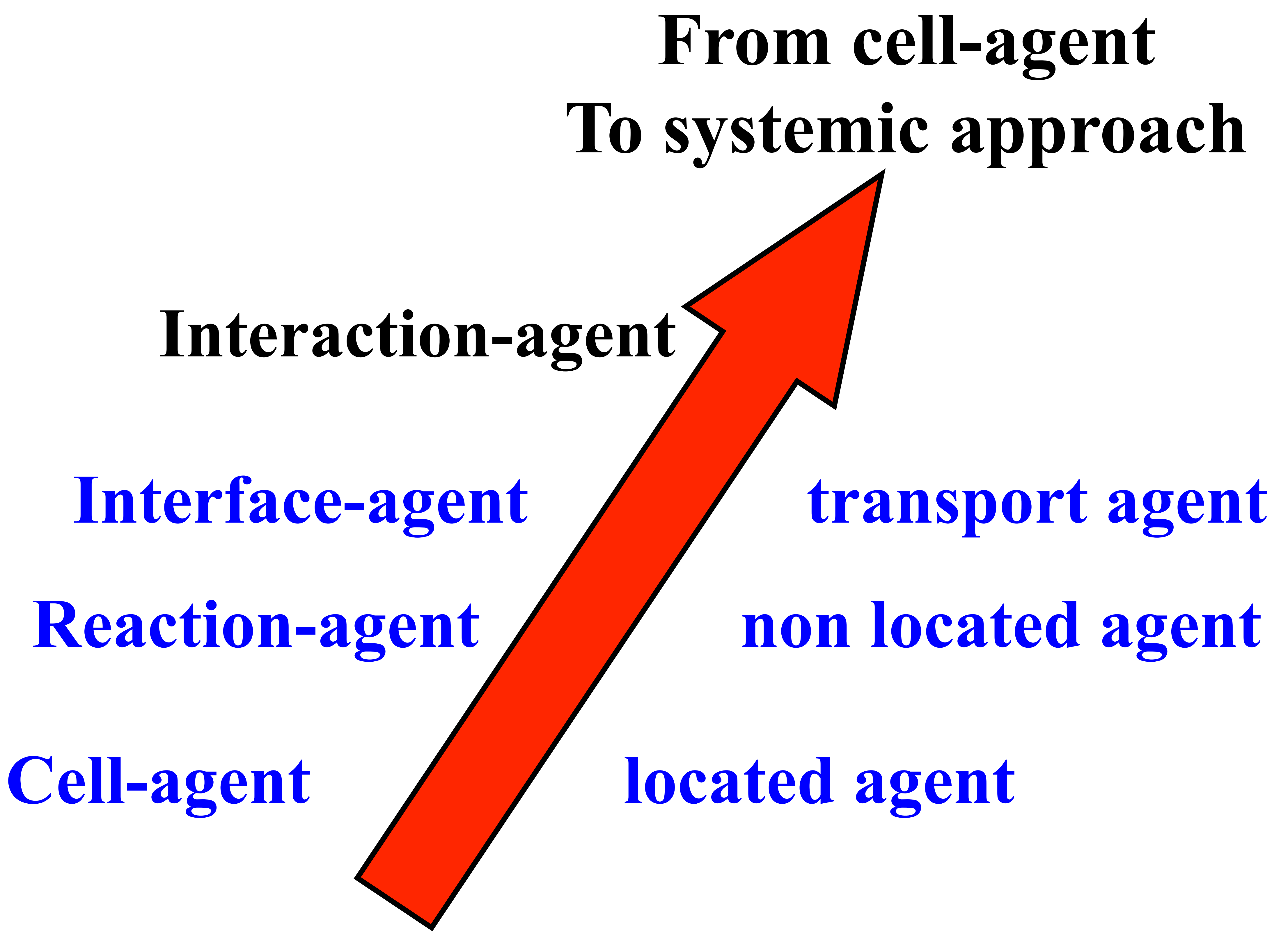
Interface-agent model:
An exemple of application

Coagulation :



3D Vessel

 Chimical Reactors : 42 reactions (coagulation)



From cell-agent
To systemic approach

Interaction-agent

Interface-agent

transport agent

Reaction-agent

non located agent

Cell-agent

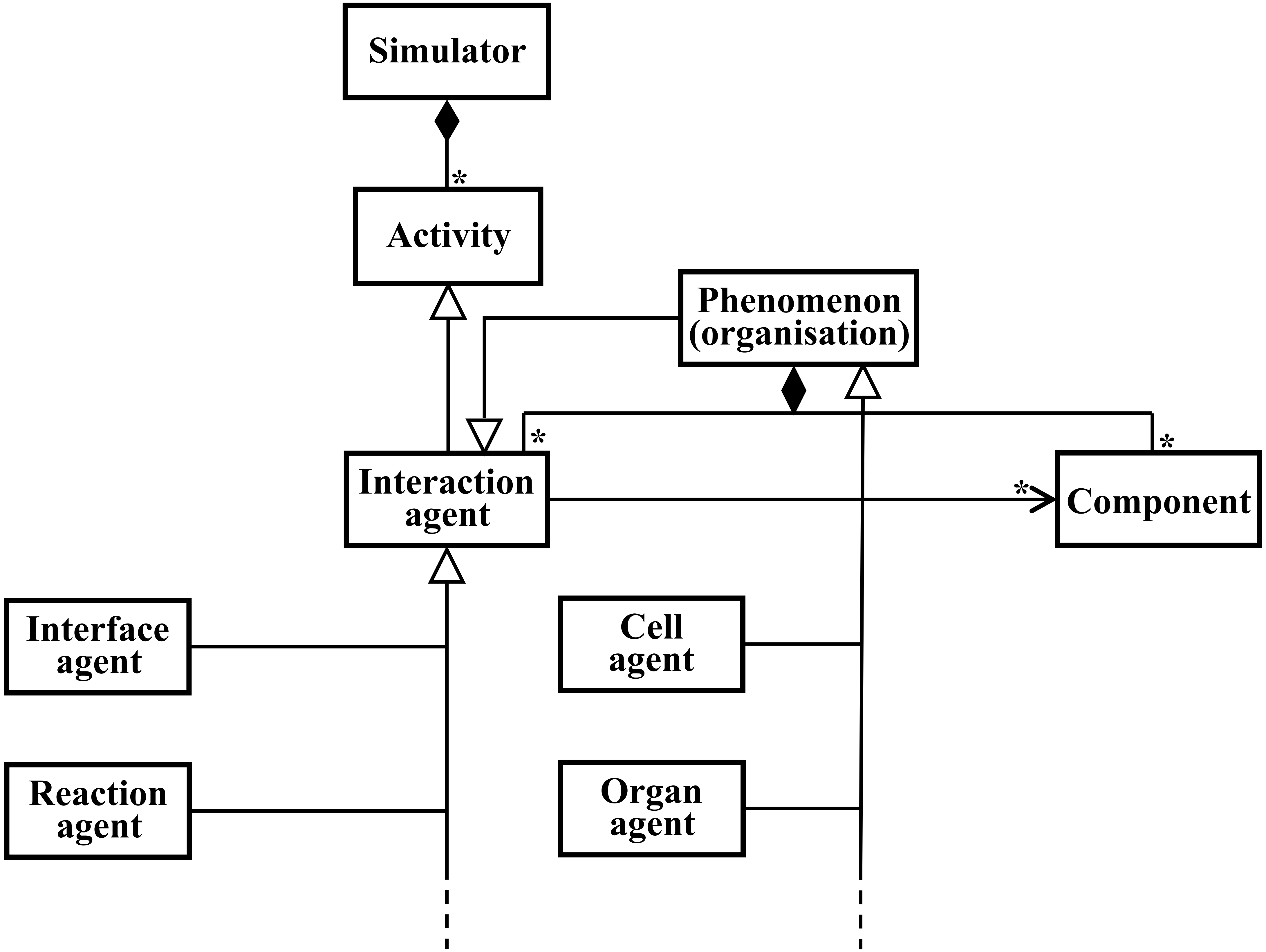
located agent

Generic model of interaction-agent

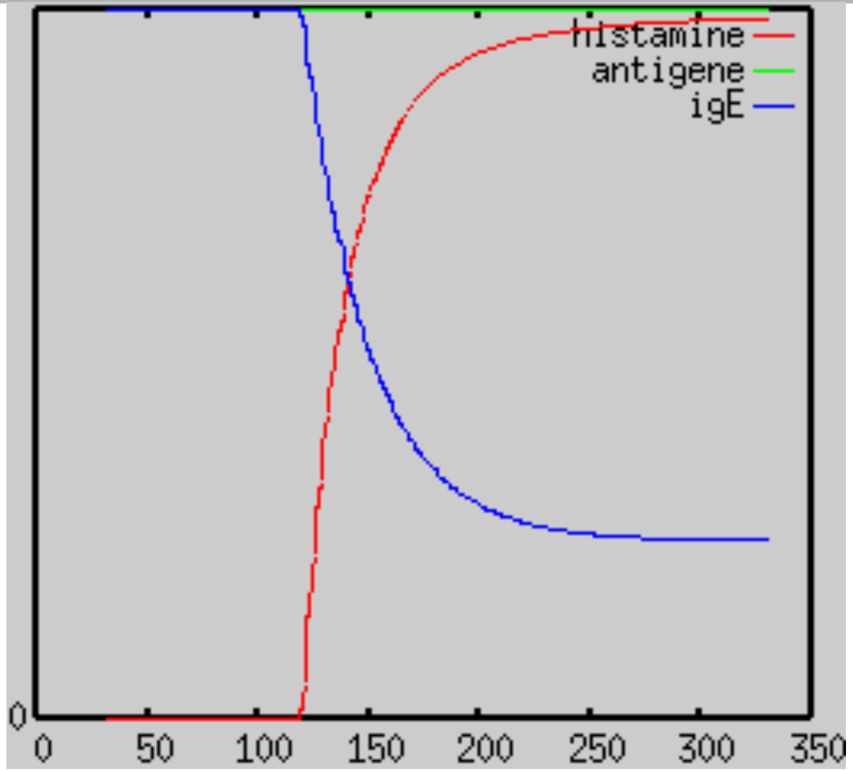
Main principle :
Models' autonomy

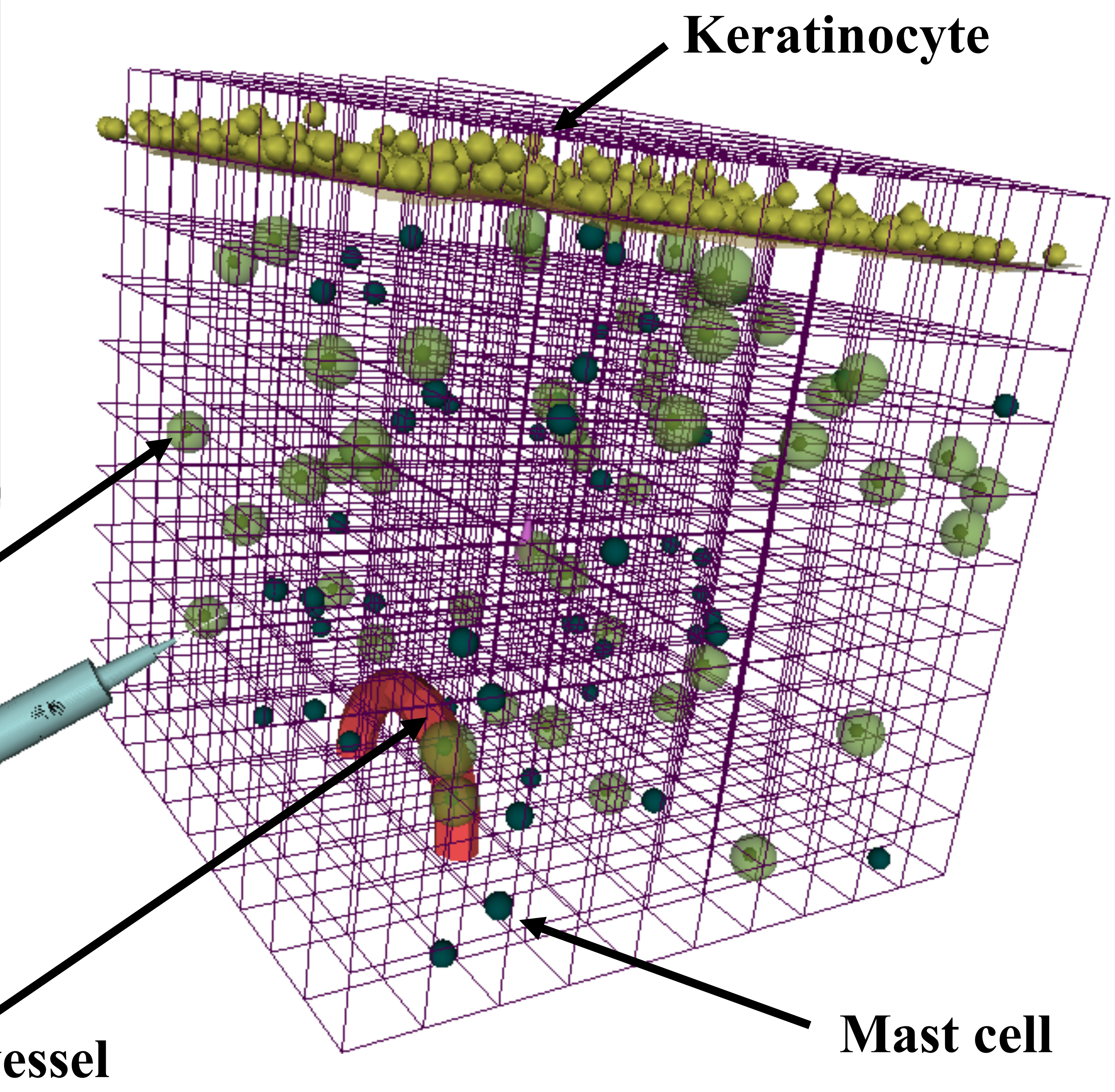
- **Interaction between models of different natures**
- **Multi-modeling Simulation**
- **Systemic paradigm**
- **Data Matter exchange between organisations**

Generic model of interaction-agent



Generic model of interaction-agent :
An exemple of application





Multi-Agent Systems and Biological modelling & simulation

From cell-agent To systemic approach

Interaction-agent

Interface-agent

Reaction-agent

Cell-agent

multimodeling

transport agent

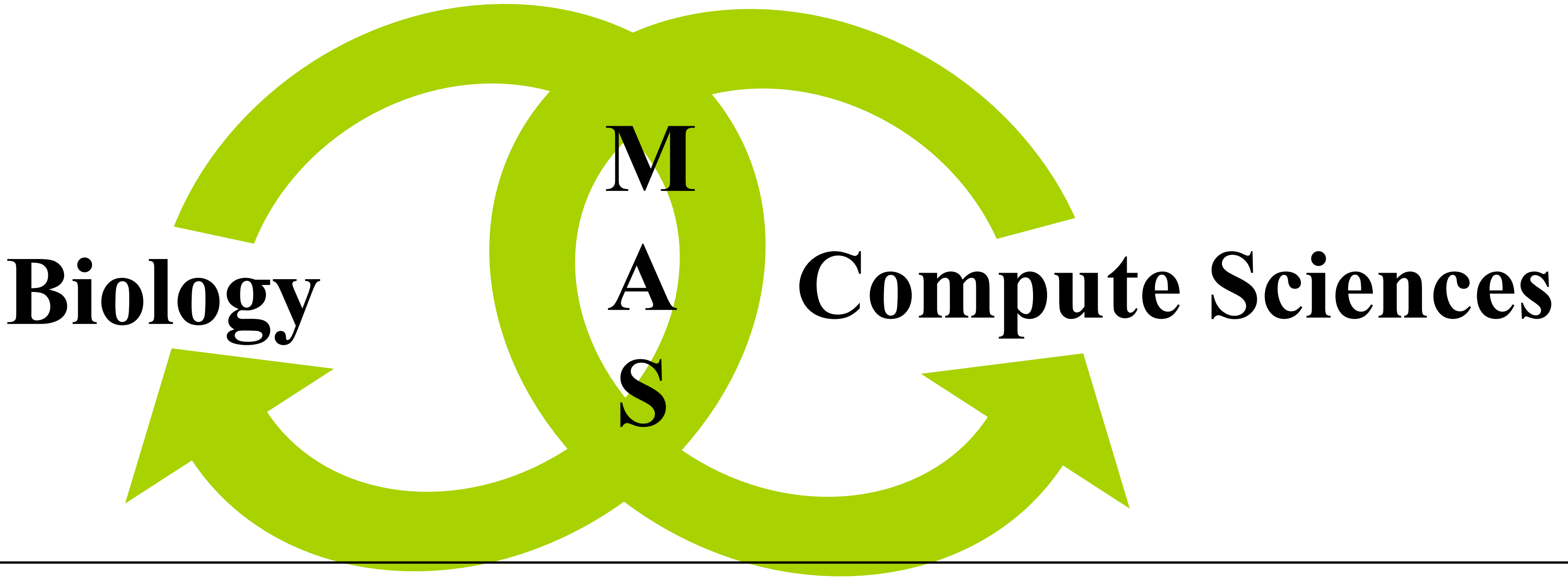
non located agent

located agent

Vincent Rodin CanTho, 19-22 december 2016

Interests in the field of biology

- To help the reflection
  - Test and validate hypotheses
  - Analyse parameters influence
  - Understand complex phenomena
- To prepare experiments
- To accelerate the drug discovery



Road map

☑ Multi-Agents Systems (MAS)

☑ From Biological environment simulation

❑ Towards Ecosystems simulation

❑ NetBioDyn software

❑ Conclusions and futur works

Towards Ecosystems simulation

Cells → Entities (insects, etc.)

&

Low level interaction

Reaction → High level interaction between entities

Interface/Interaction → Physical environment

Road map

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☐ Conclusions and futur works

NetBioDyn software : an easy to use multi-agents engine

Goal:
Rapid prototyping of
biological & ecosystem simulations

http://virtulab.univ-brest.fr/netbiodyn.html

http://virtulab.univ-brest.fr/netbiodyn3D.html

NetBioDyn software :
an easy to use multi-agents engine

Key concepts:

➔Environment: a grid

➔Entities: colored squares

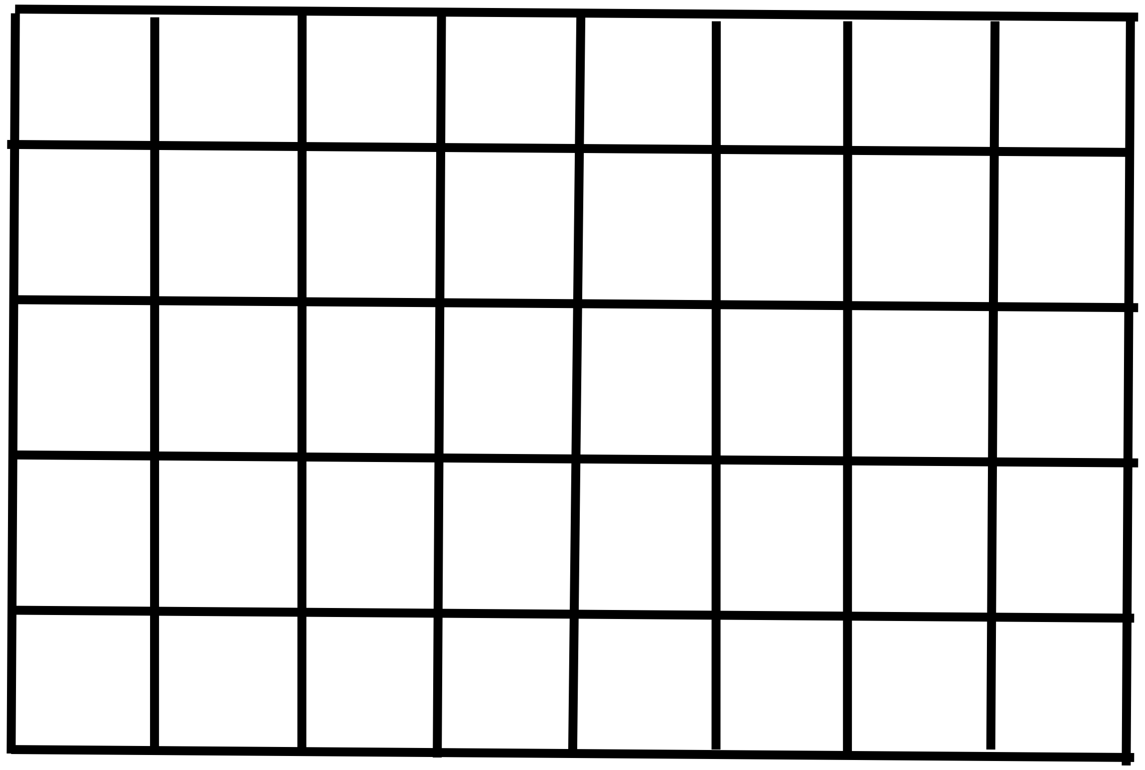
➔Interaction with environment : simple rules

➔Interaction between entities : simple rules

Easy to use… No programming skill requires !!!!

NetBioDyn software : How to model…?

1st : take a grid



2nd : decide which entities to use

🟥 🟩 ….. 🟦

3rd : define rules (with a probility of activation) to give entities movements and interactions

🟥 + Ø → Ø + 🟥 P=1 (go to the right)

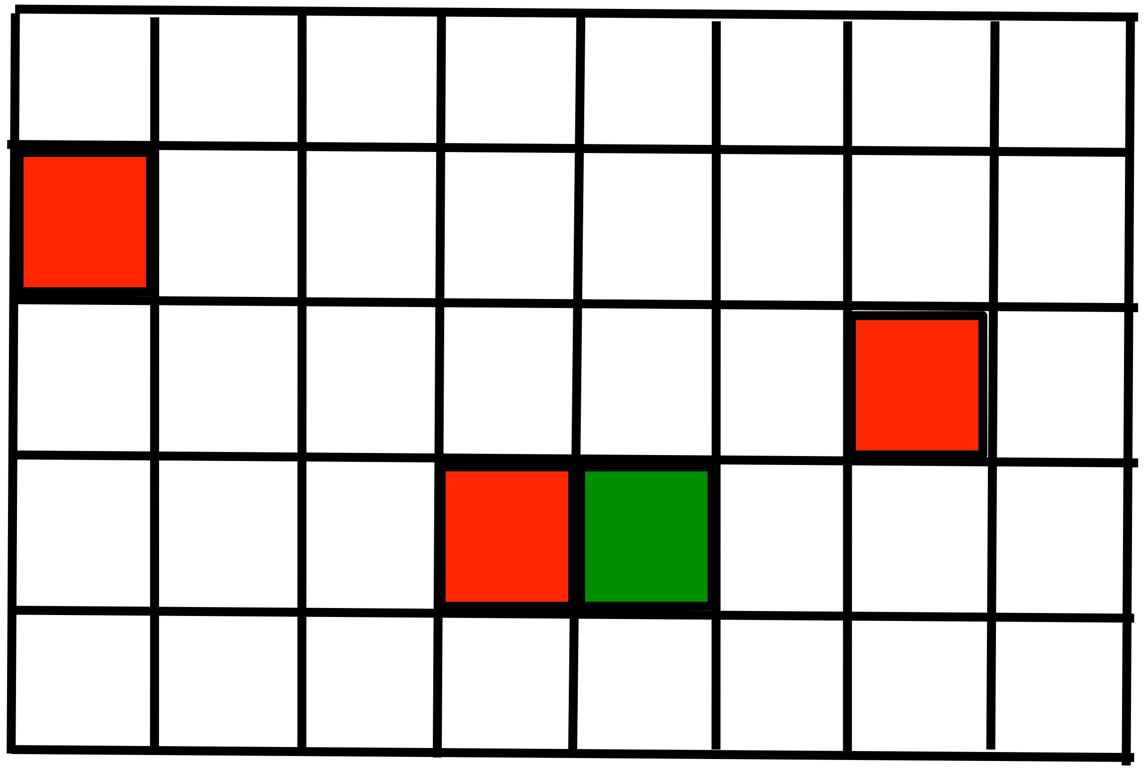
🟥 + 🟩 → 🟥 + 🟥 P=0.5 (contamination)

…..

NetBioDyn software : How to model…?

4th : place entities

and : run



🟥 + □ → □ + 🟥 (go to the right)

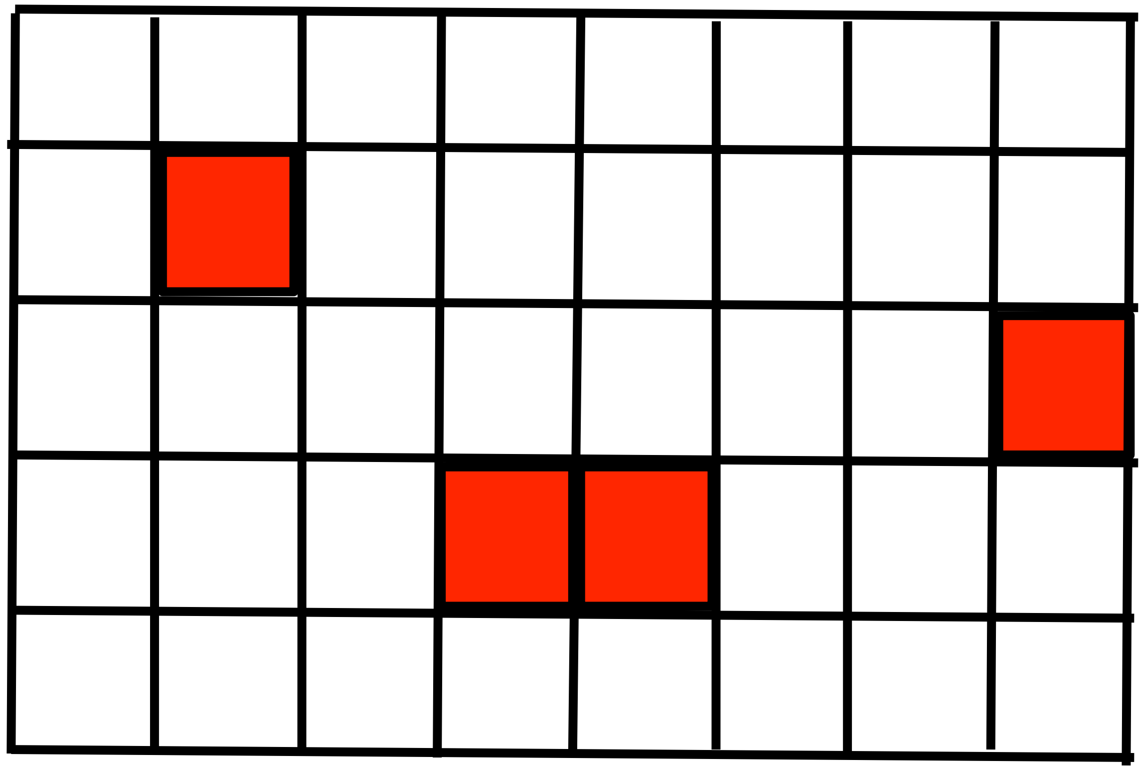
🟥 + 🟩 → 🟥 + 🟥 (contamination)

•••••

NetBioDyn software : How to model...?

4th : place entities

and : run ❯



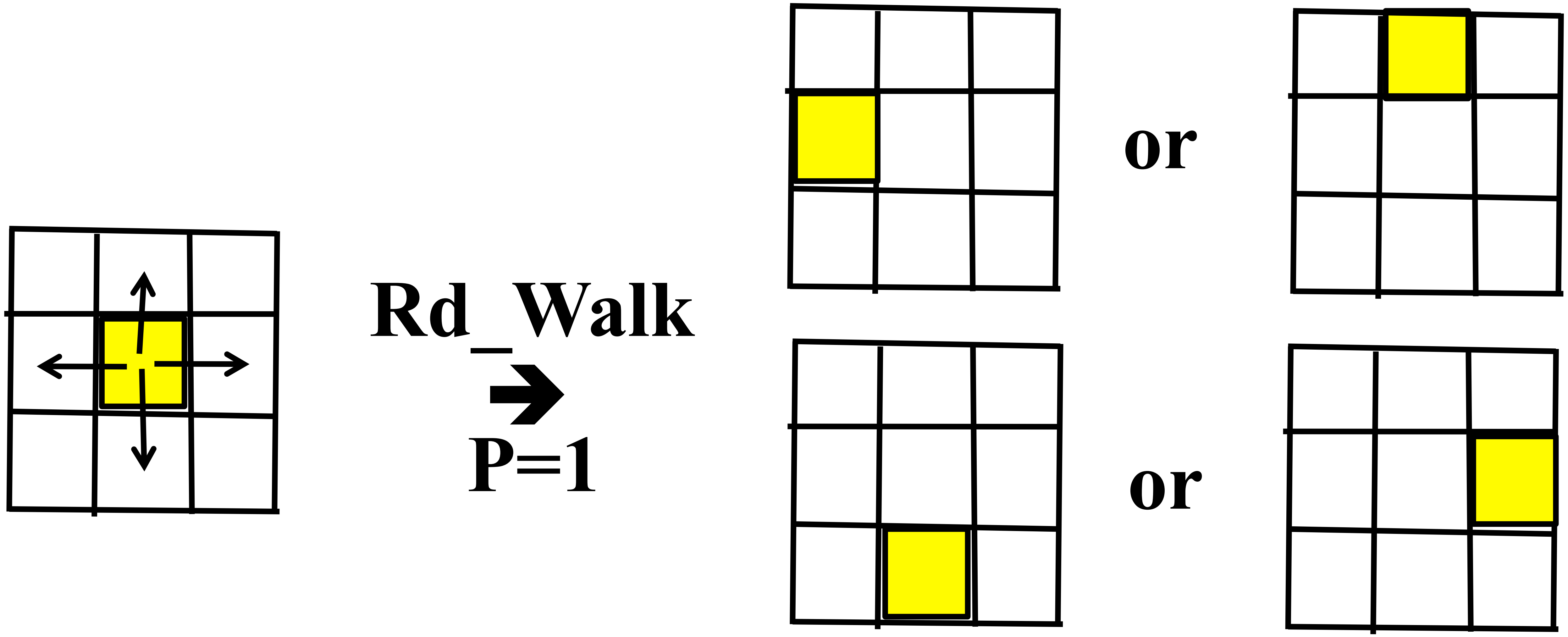
🟥 + ⬜ → ⬜ + 🟥 (go to the right)

🟥 + 🟩 → 🟥 + 🟥 (contamination)

.....

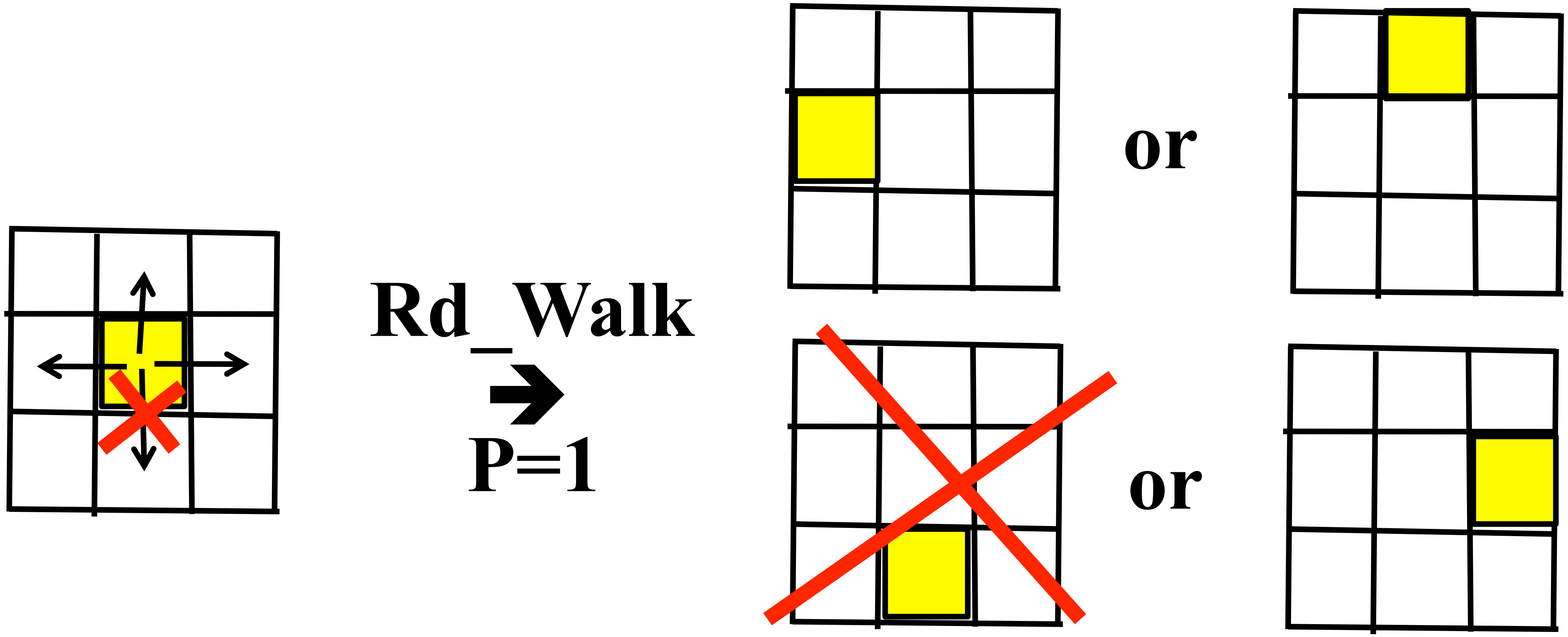
NetBioDyn : 1st example, randomwalk

➔Entities: 🟨



NetBioDyn : 1st example, randomwalk

➔Entities: 🟨



Rd_Walk

➔

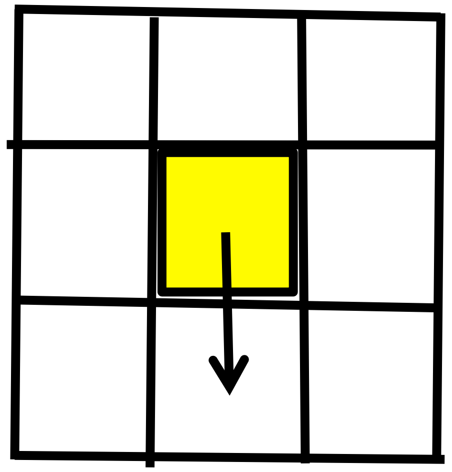
P=1

or

or

NetBioDyn : 2nd example, sandglass

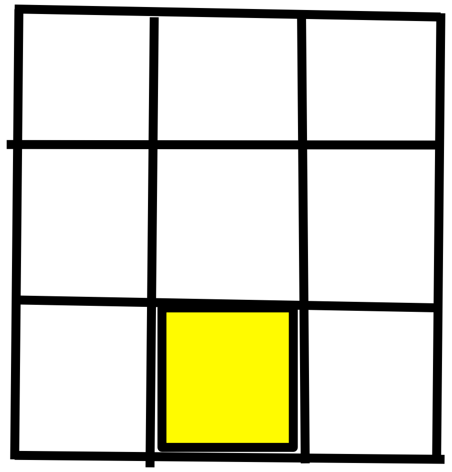
➔Entities: grain 🟨 and border ⬛

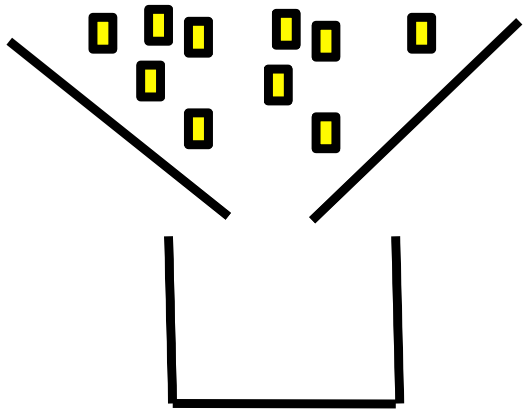


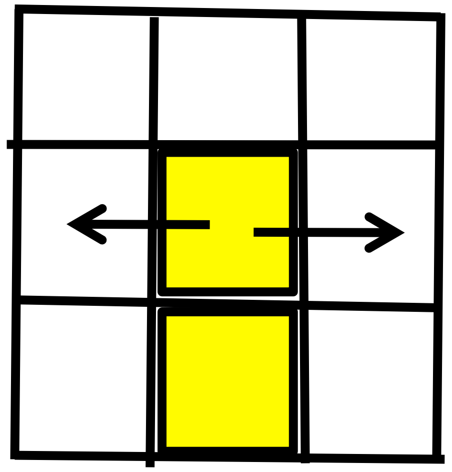
Go_Down

➔

P=1



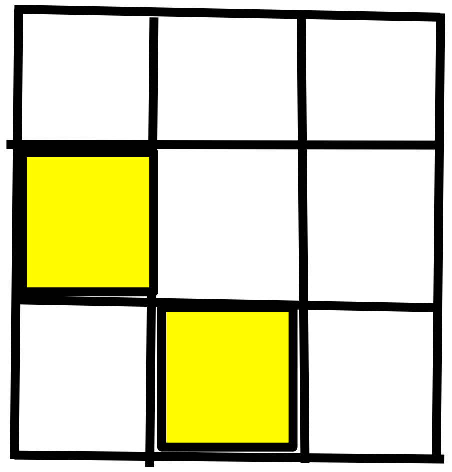




Go_LeftRight

➔

P=0.5



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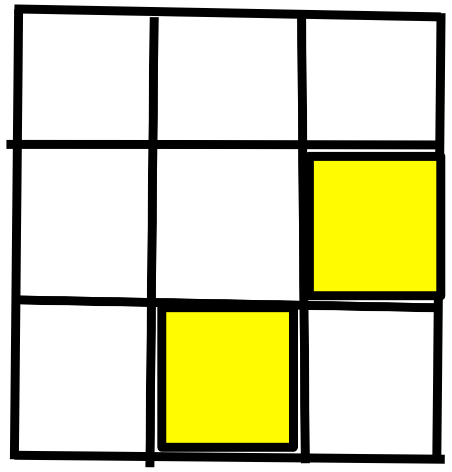
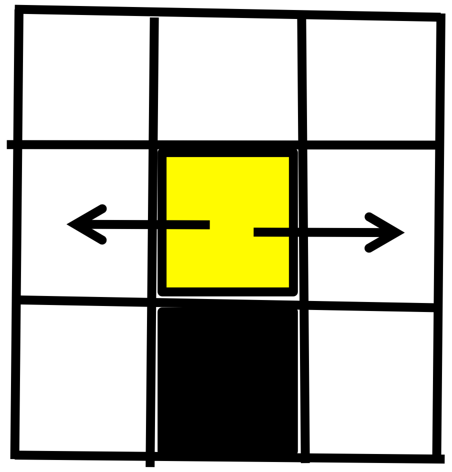
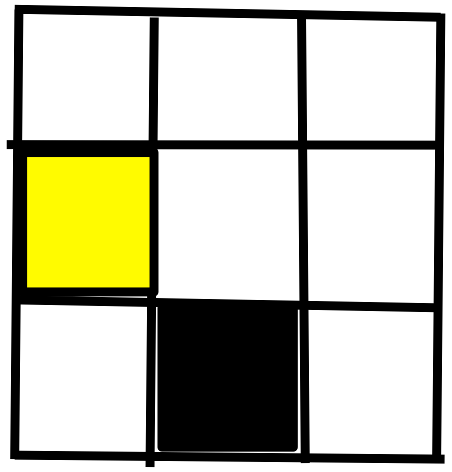




Go_Border

➔

P=0.75



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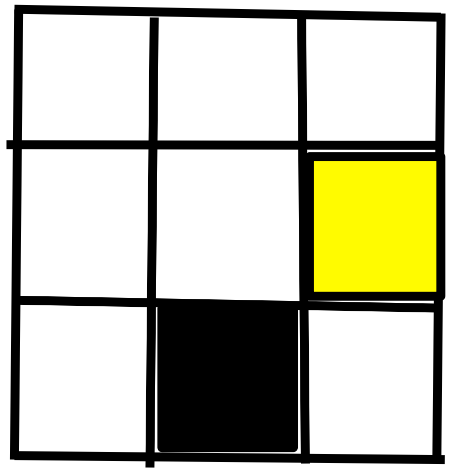
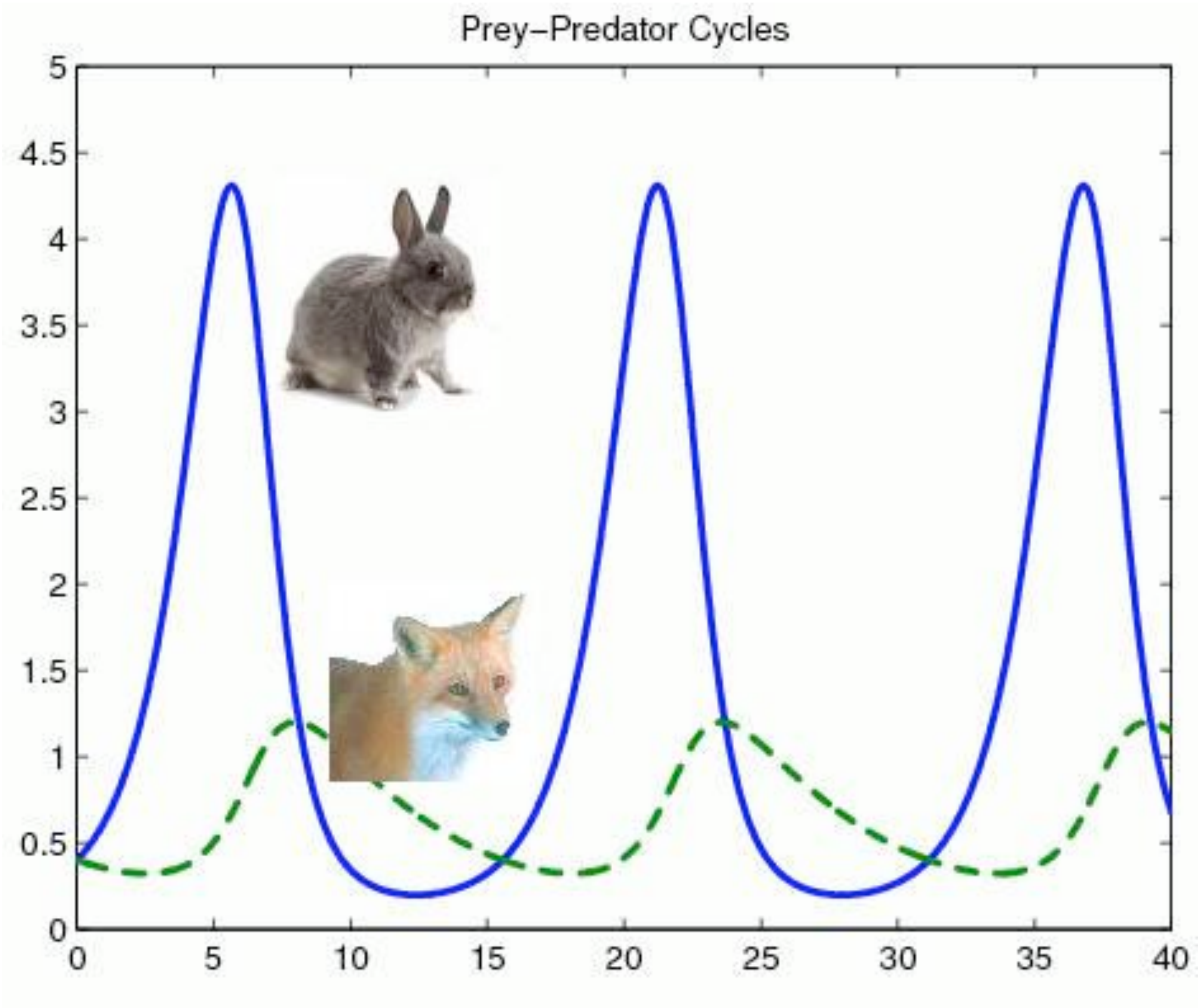


NetBioDyn : 3rd example, prey-predator

➔Entities: prey 🟦 and predator 🟩

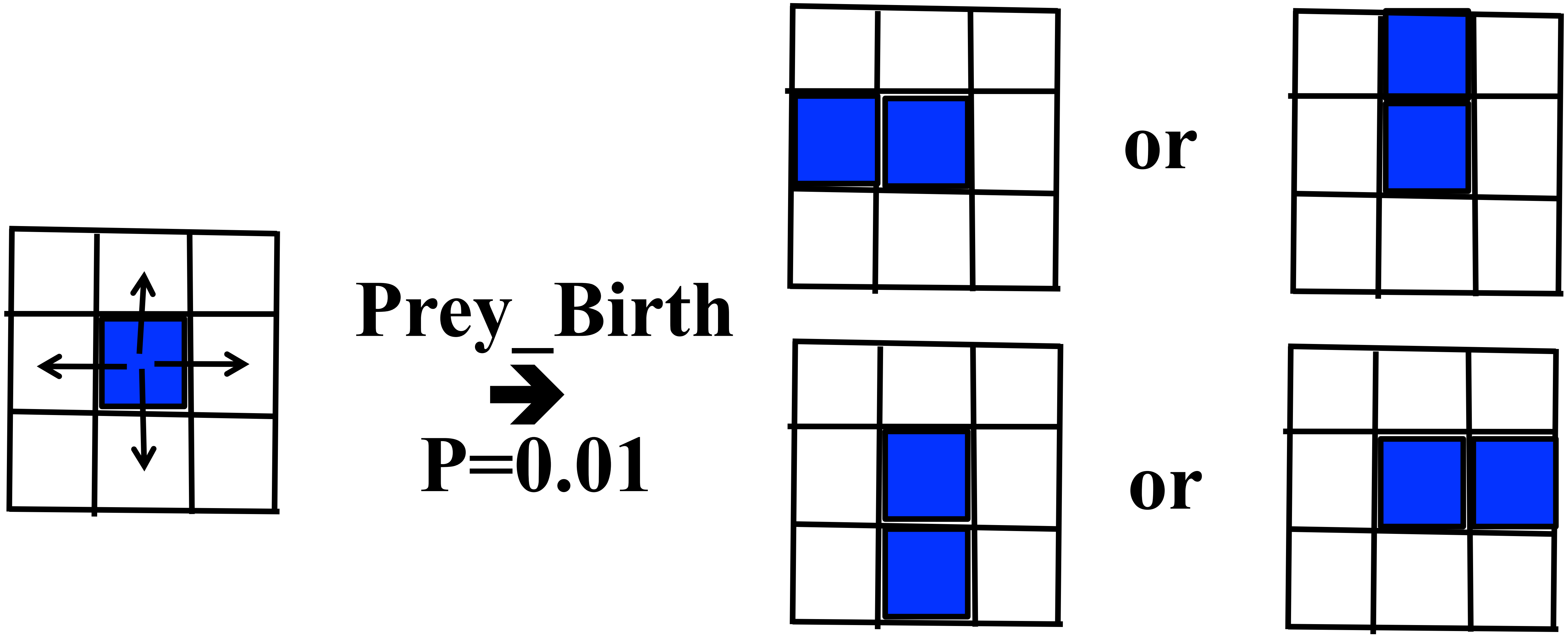
Prey 🟦 ½ life time : 2000 cycles + **Rd_Walk**

Predator 🟩 ½ life time : 200 cycles + **Rd_Walk**



NetBioDyn : 3rd example, prey-predator

➔Entities: prey 🟦 and predator 🟩



Prey_Birth

➔

P=0.01

or

or

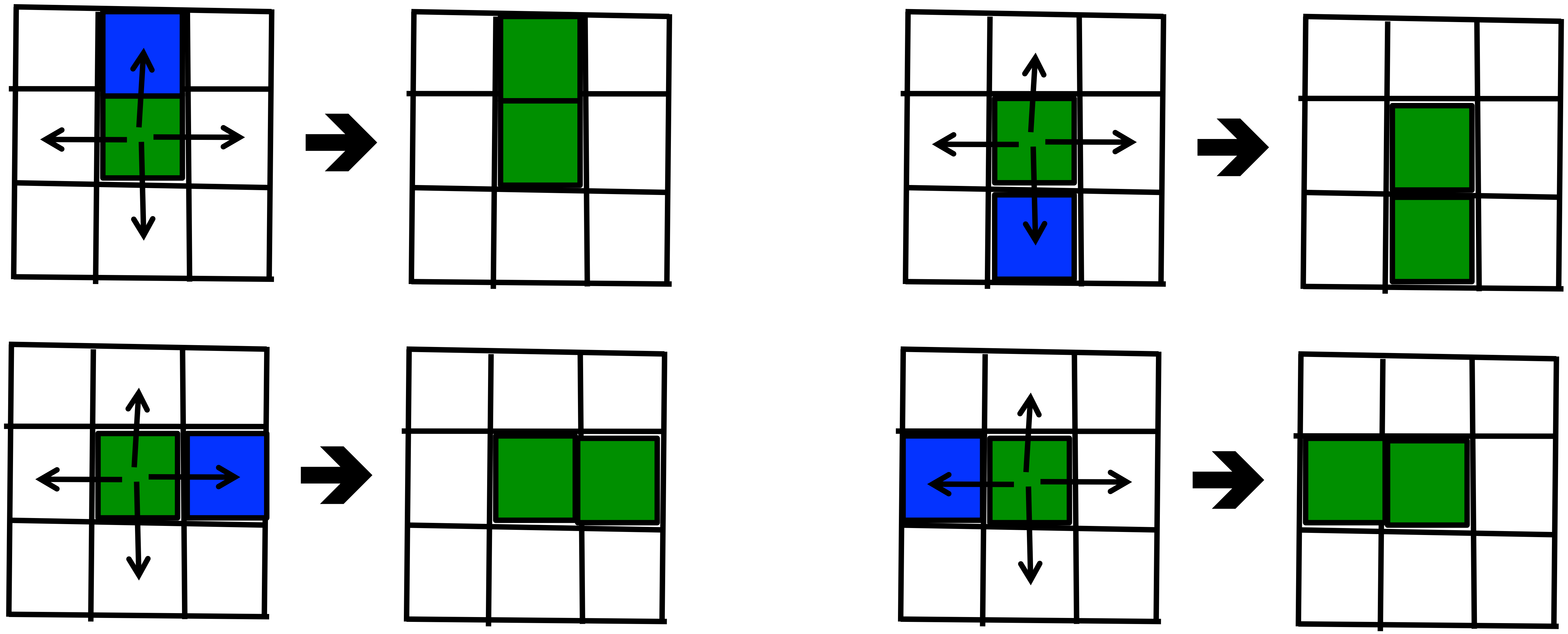
NetBioDyn : 3rd example, prey-predator

→Entities: prey 🟦 and predator 🟩

Predator_Prey

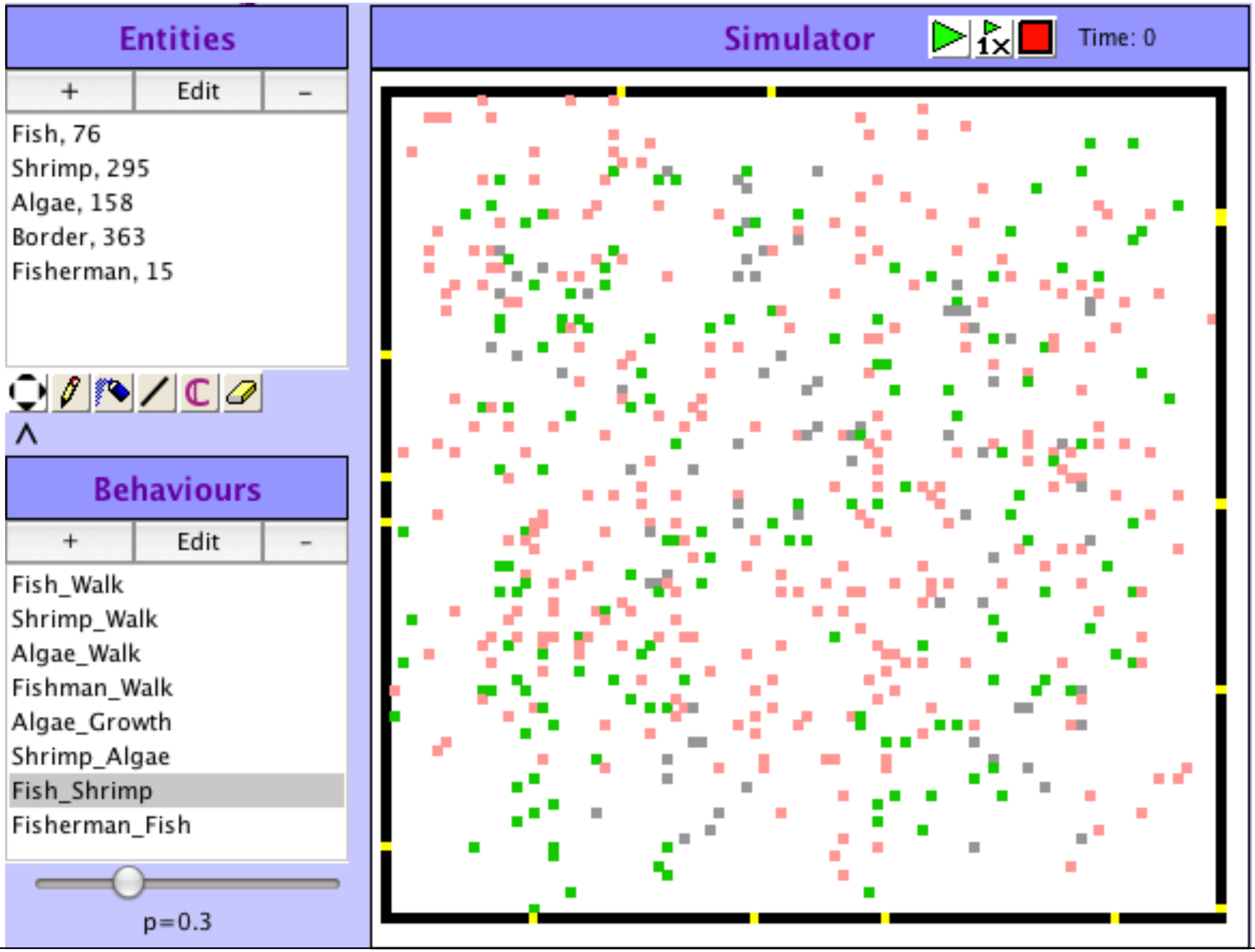
→

P=0.6



NetBioDyn : 4th example, fish farm

➔Entities: fish ▨ , shrimp 🟥, algae 🟩 , fisherman 🟨 , border ⬛



Entities

+ Edit –

Fish, 76
Shrimp, 295
Algae, 158
Border, 363
Fisherman, 15

Behaviours

+ Edit –

Fish_Walk
Shrimp_Walk
Algae_Walk
Fishman_Walk
Algae_Growth
Shrimp_Algae
Fish_Shrimp
Fisherman_Fish

p=0.3

Simulator

Time: 0

NetBioDyn : 4th example, fish farm

➔Entities: fish ⬜ , shrimp 🟪, algae 🟩 , fisherman 🟨 , border ⬛

Entities :

Fish:	1/2 Life = 150.0
Shrimp:	1/2 Life = 200.0
Algae:	1/2 Life = infinite
Border:	1/2 Life = infinite
Fisherman:	1/2 Life = infinite

Behaviors :

Fish_Walk :	p=1.0,	Fish + 0 + *	➔ 0 + Fish + *
Shrimp_Walk :	p=1.0,	Shrimp + 0 + *	➔ 0 + Shrimp + *
Algae_Walk :	p=0.3,	Algae + 0 + *	➔ 0 + Algae + *
Fishman_Walk :	p=0.1,	Fisherman + Border + *	➔ Border + Fisherman + *
Algae_Growth :	p=0.02,	Algae + 0 + *	➔ Algae + Algae + *
Shrimp_Algae :	p=0.6,	Shrimp + Algae + *	➔ Shrimp + Shrimp + *
Fish_Shrimp :	p=0.3,	Fish + Shrimp + *	➔ Fish + Fish + *
Fisherman_Fish :	p=1.0,	Fisherman + Fish + *	➔ Fisherman + + *

Road map

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☑ NetBioDyn software

□ Conclusions and futur works

NetBioDyn : Conclusion

- ➢ **Advantage:** ➔ very simple (entities, rules)

  ➔ no programming !

Example: 🟨 + Ø ➔ Ø + 🟨 (movement)

…………….

- ➢ **Drawback:** ➔ very simple (entities, rules)

  ➔ no entity's state !

Example: 🟨 + * ➔ 🟩 + * (new entity's state)

…………….

➔ new entity !

NetBioDyn : futur works

- Self-ajusting parameters…

  ➔ a great challenge !

- Entity's state (simply an integer)…

  ➔ Building a model would be simpler by minimizing the nb of « different » entities