

# Biosys-Lideogram



Visualisation et apprentissage automatique pour  
une modélisation interactive d'un bio-système

Nathalie Marie MEJEAN

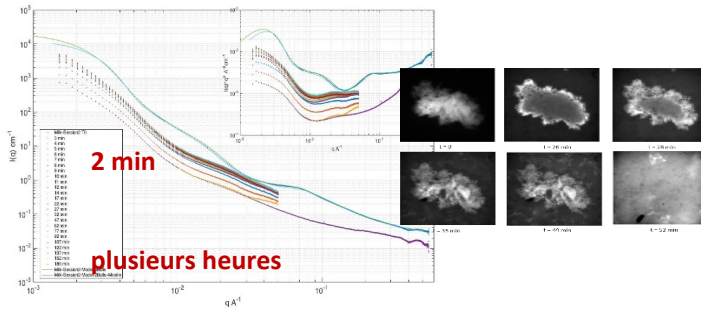
Nadia Boukhelifa, Evelyne Lutton, Alberto Tonda and Co  
Fernanda Fonseca et Severine Layec pour l'application

# Biosys-Lideogram

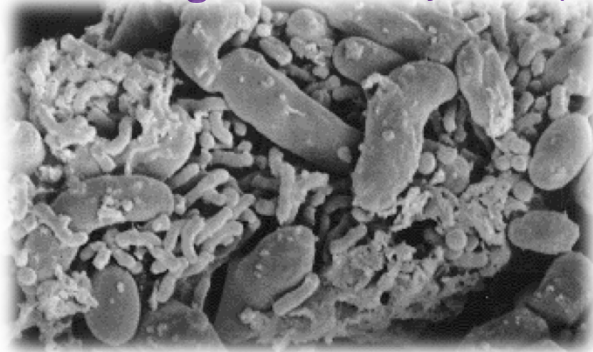
## Avant Propos

Des cinétiques à temps variables et échelles variables

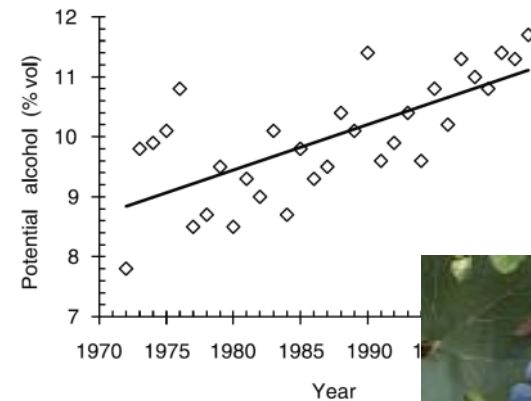
### Cinétiques de digestion



Cinétiques bactériennes pour représenter l'affinage de fromages *environ 15 jours ou plus*

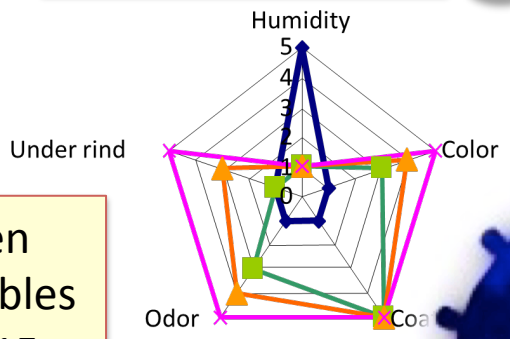


### Cinétiques lentes du climat



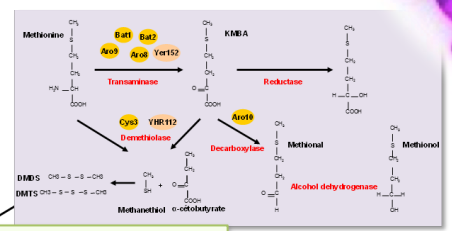
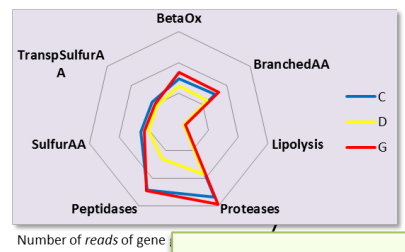
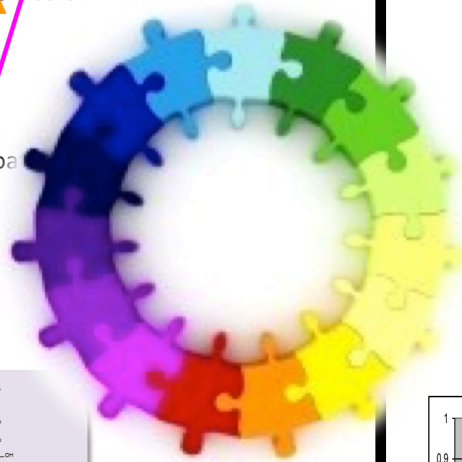
# Big Data... & Sparse Data

Sensory space en moyenne 10 variables symboliques, 8-15 cinétiques

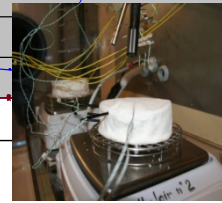
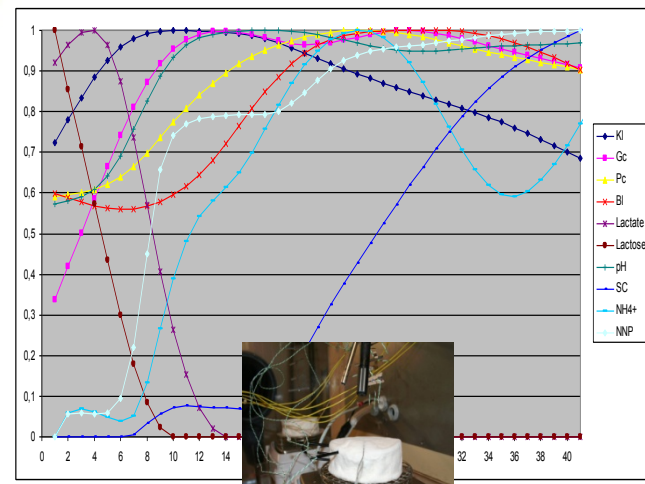
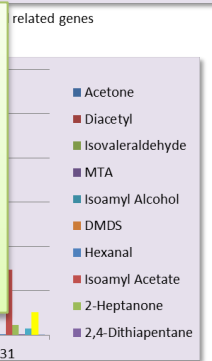


Microorganisms space moyenne 15 variables numériques, 8-15 cinétiques

Sicard et al. 2011, Expert Systems with Applications, 38(9), 11804-11812.

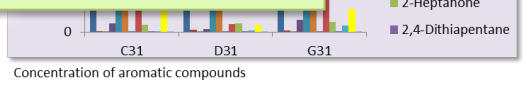


Genomic space sur 1 écosystème de 9 microorg., 40000 expressions de gènes et 3 expériences



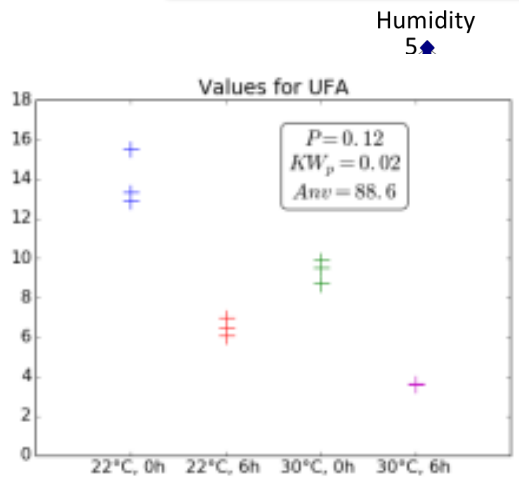
Experiments

Dugat Bony et al., 2016



# Big Data... & Sparse Data

Sensory  
moyenne  
symbolique  
cinématique

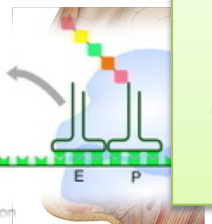
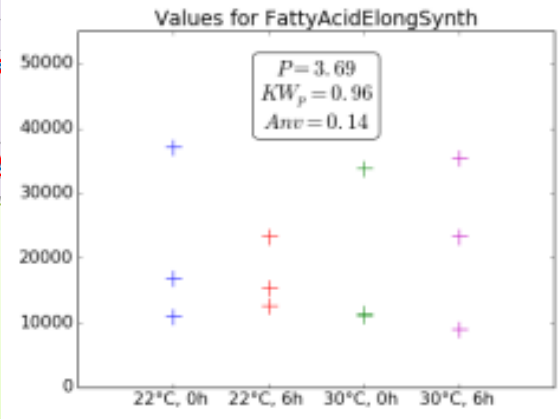
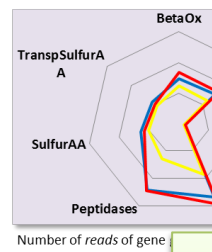


Color

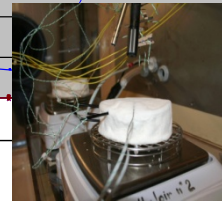
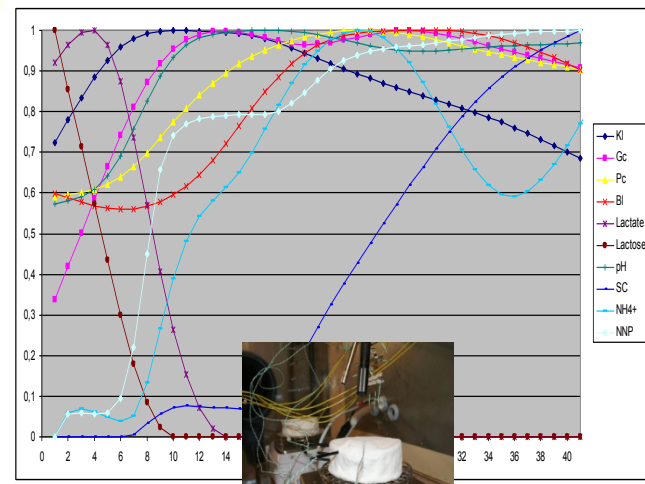
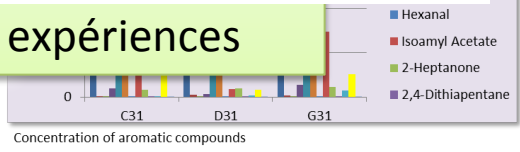


Microorganisms space  
moyenne 15 variables  
numériques, 8-15  
cinématiques

Sicard et al. 2011, Expert Systems with Applications, 38(9), 11804-11812.



et 3 expériences

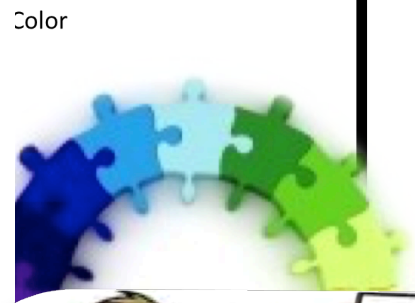
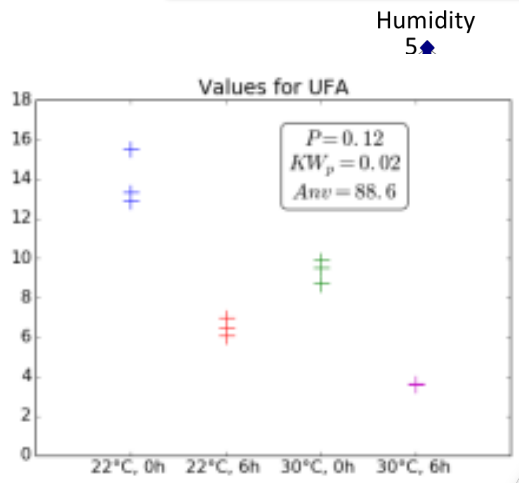


Experiments

Dugat Bony et al., 2016

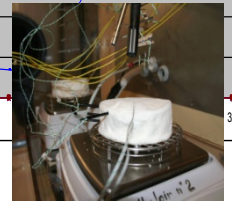
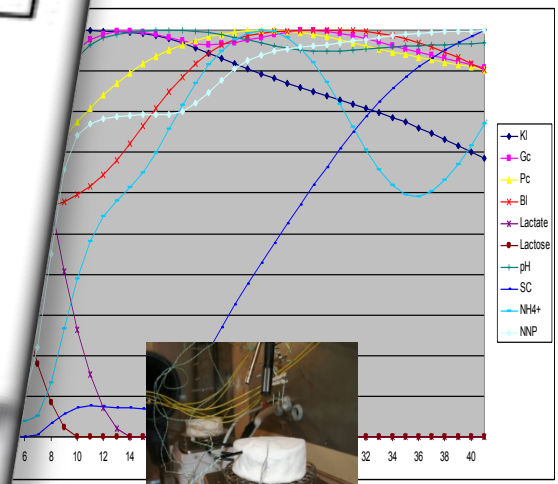
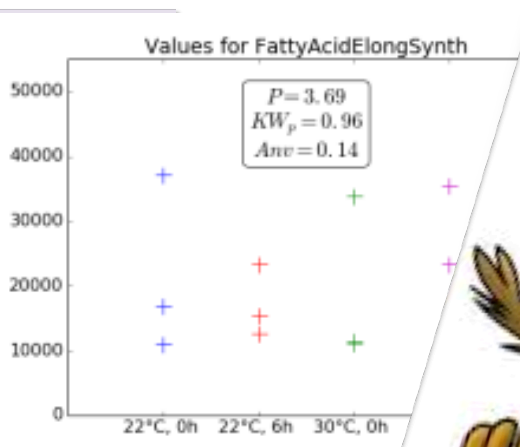
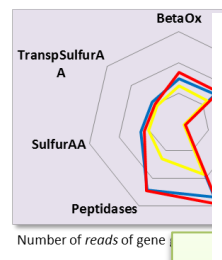
# Big Data... & Sparse Data

Sensory  
moyenne  
symbolique  
cinématique



Microorganisms space  
moyenne 15 variables  
numériques, 8-15  
cinétiques

Sicard et al. 2011, Expert Systems with Applications, 38(9), 11804-11812.



Experiments

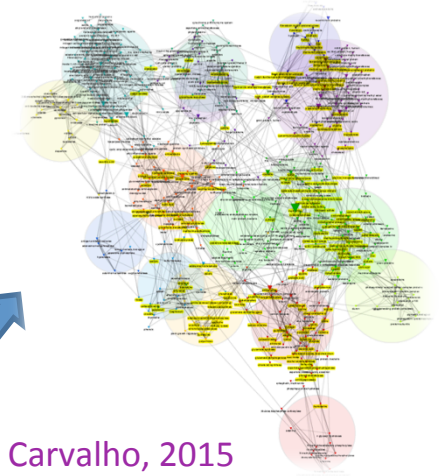
et 3 expériences

Dugat Bony et al., 2016





Perrot et al., 2015, Plosone  
 Sicard et al., 2011 Expert systems  
 Agioux et al., 2004, Allais et al.,  
 2011 food engineering

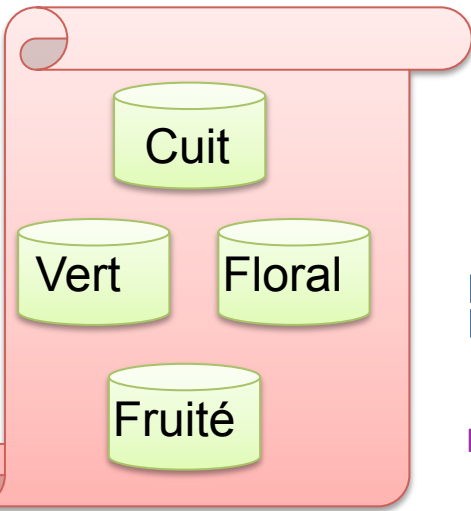


De Carvalho, 2015

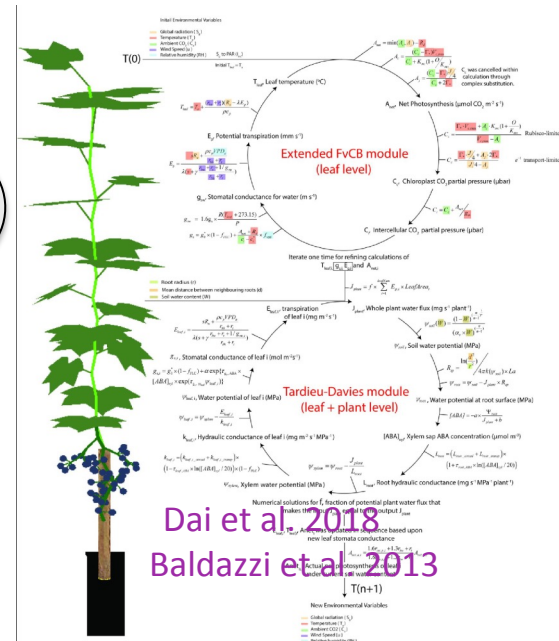
SI  fort et



faible ALORS sucre



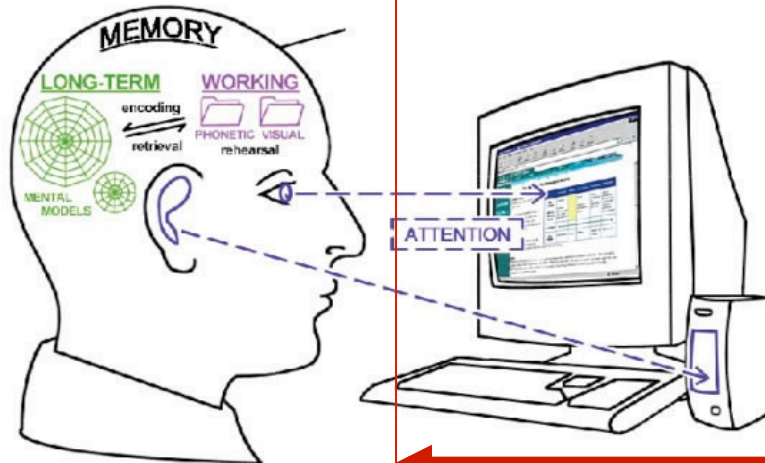
Roche et al. 2018



# Biosys-Lideogram: un travail d'équipe

## Symbolique:

Contraintes explicites sous formes de règles ou de contraintes



## Sub-symbolique:

Connaissances non déclaratives

## Étape 1

Liens explicites entre variables.  
Formes mathématiques :  
graphes, contraintes, classes, règles



## Étape 2

Apprentissage, Optimisation  
Émergence itérative d'un modèle.

*Exploration itérative de modèles*  
**Interactions fondées sur la Visualisation**

# Biosys-Lideogram

## L'application: production/stabilisation de bactéries lactiques



4 échelles:

- **Transcriptomique:** pour expression de 2744 genes;
- **Cellulaire:** 7 variables;
- **Population:** 3 variables;
- **Population-Bioprocess:** 4 ET 2 conditions procédé

4 expériences répétées 3 fois: 12 points de mesure

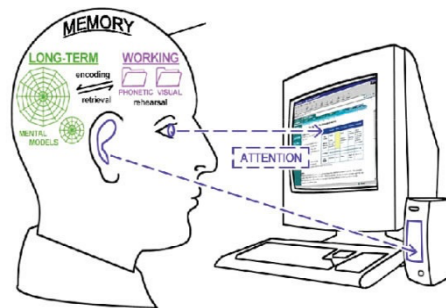


UMR SayFood

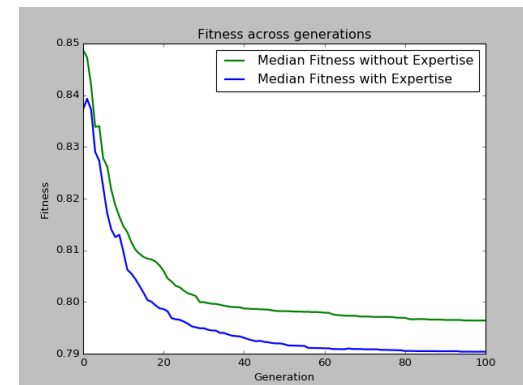


Micalis Institute, UMR1319

13/09/23

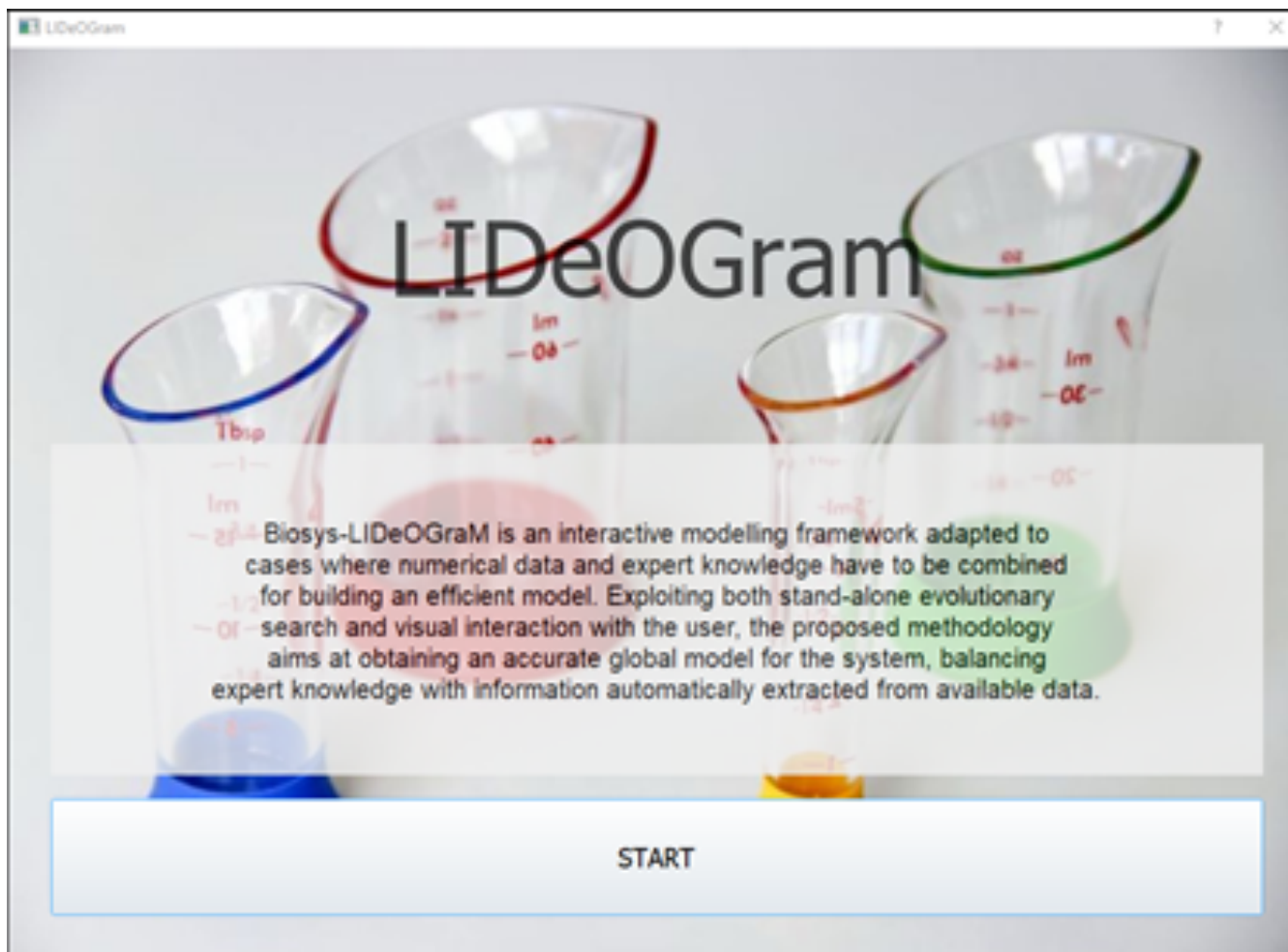


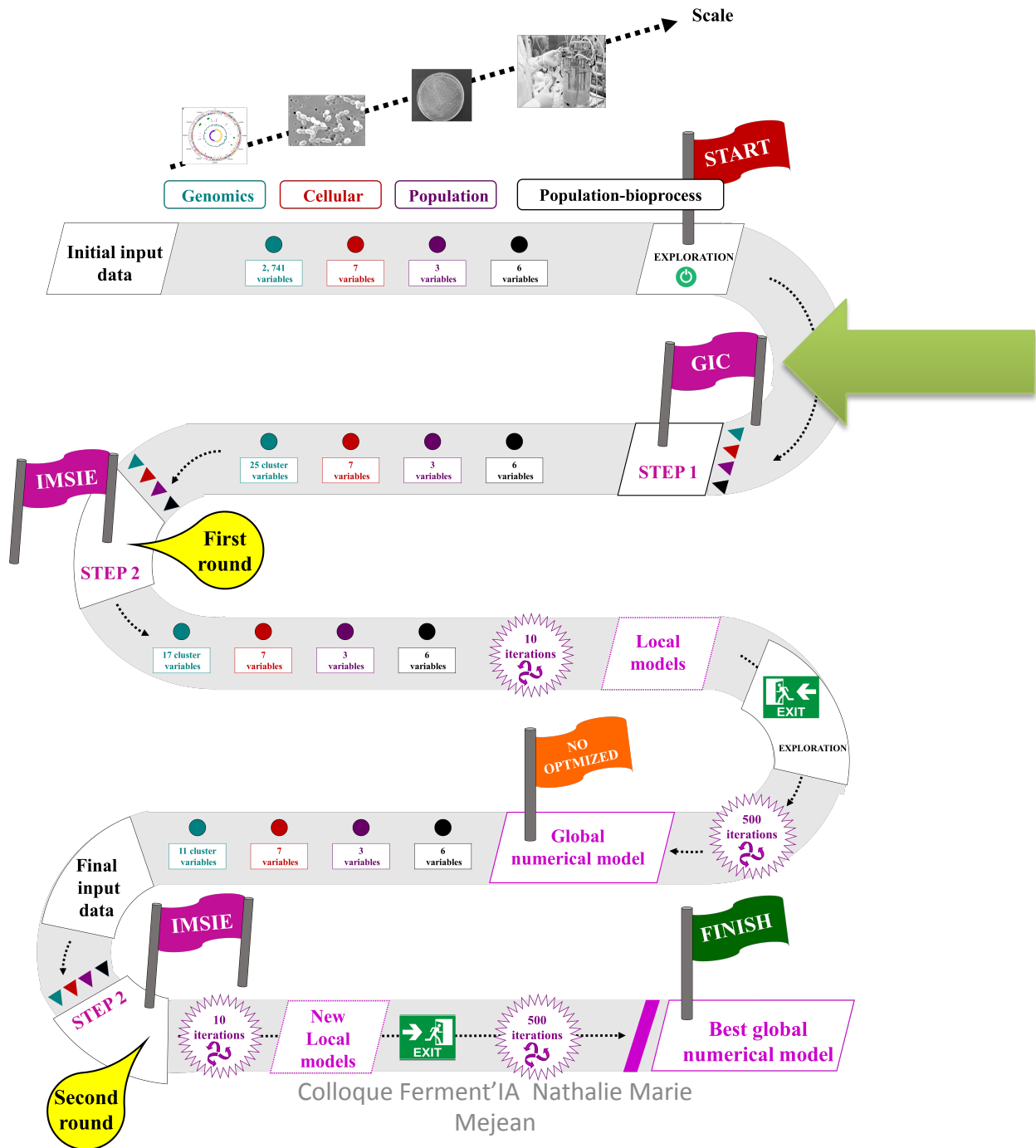
Colloque Ferment IA Nathalie Marie Mejean



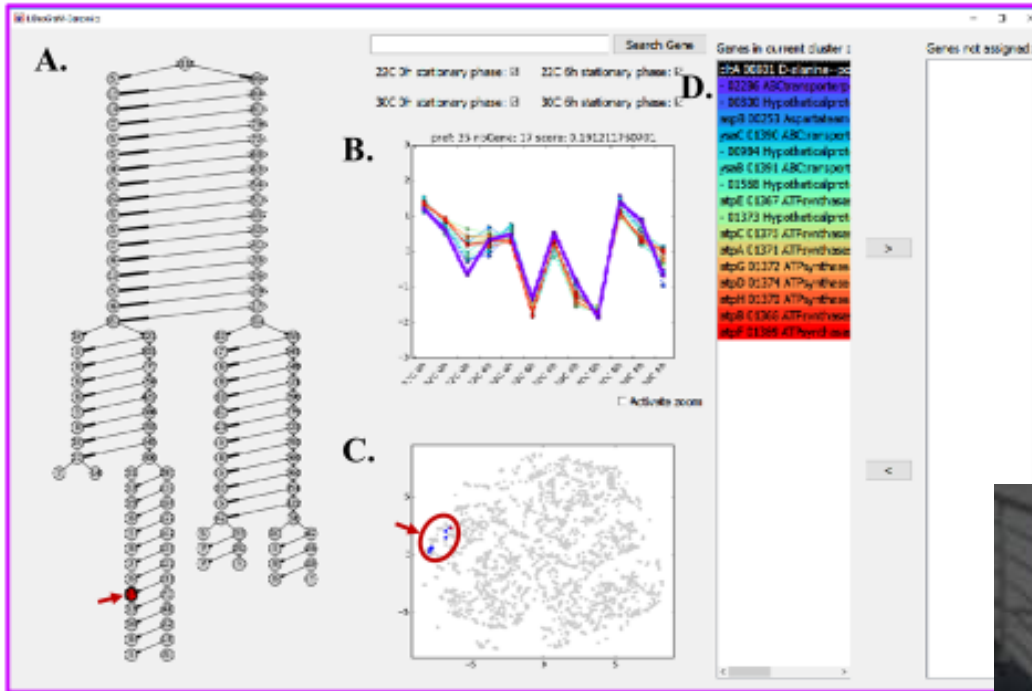
$\mu$	100
$\lambda$	80
Crossover probability	0,8
Mutation probability	0,2
Number of generations	100
Selection	Tournament of size 2



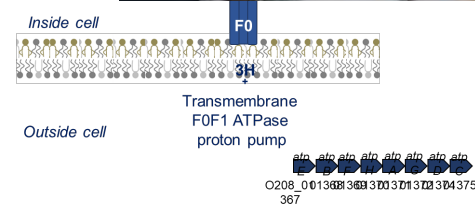


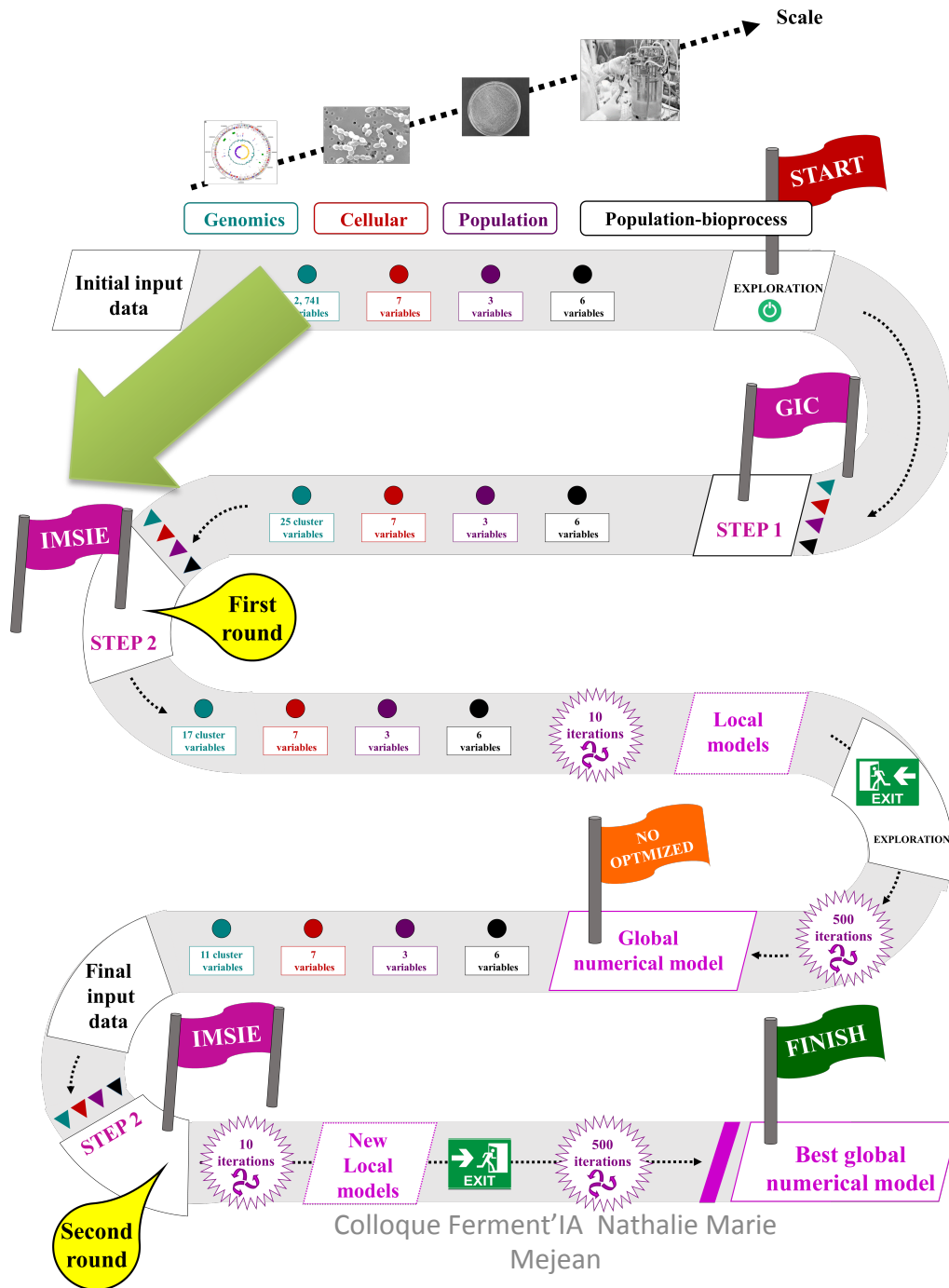


# GIC step



Proton Pump





# IMSIE Graph construction

**A. Classes Management**

- + Genes\_clusters -> Popul...
- + Genes\_clusters -> Cell
- + Genes\_clusters -> Cell\_A
- + Cell\_Anisotropy -> Popul...
- + Cell -> Population
- + Cell -> Cell\_Anisotropy
- + condition -> Population
- + condition -> Cell
- + condition -> Cell\_Anisotr...
- Purine\_metabolism's assign...
- WTAs\_biosynthesis's assign...
- EPS\_synthesis's assignatic...

**B. Graph**

Graph nodes: condition, Genes\_clusters, Cell, Population, Cell\_Anisotropy.

**C. Assigned to Genes\_clusters :**

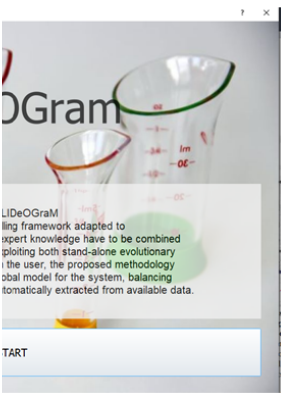
- Glycerol\_transporters
- D\_alanylationof\_WTAs
- Galactose\_transporter
- Galactose\_conversion
- Proton\_pump
- Fatty\_acids\_biosynthesis
- L\_LDH\_transporter
- L\_LDH
- Copper\_exporting\_ATPase
- Quinone\_detoxification
- Arginine\_Glutamate

**D. Not assigned :**

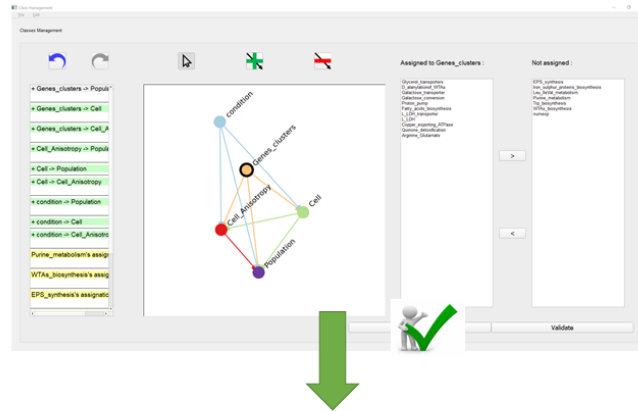
- EPS\_synthesis
- Iron\_sulphur\_proteins\_biosynthesis
- Leu\_IleVal\_metabolism
- Purine\_metabolism
- Trp\_biosynthesis
- WTAs\_biosynthesis
- numexp

Buttons: Cancel, Validate

# IMSIE Local exploration >> global model



**Graph  
(step 2.1)**

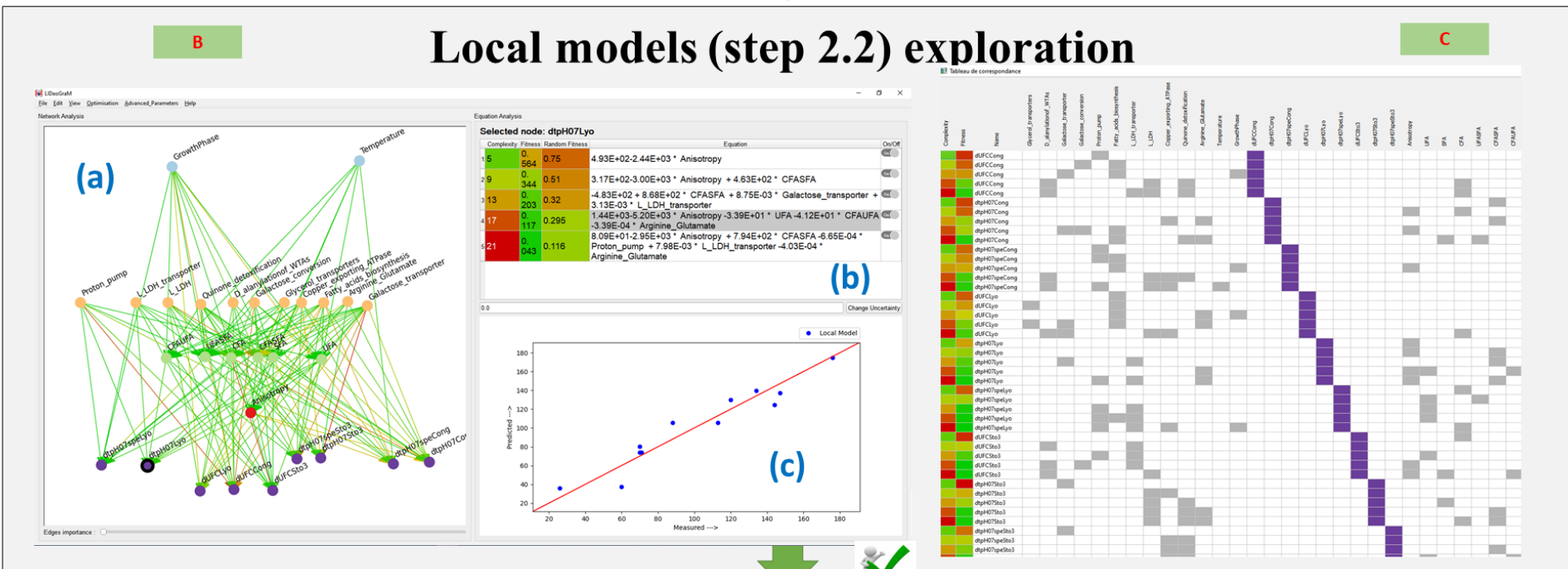


**A**

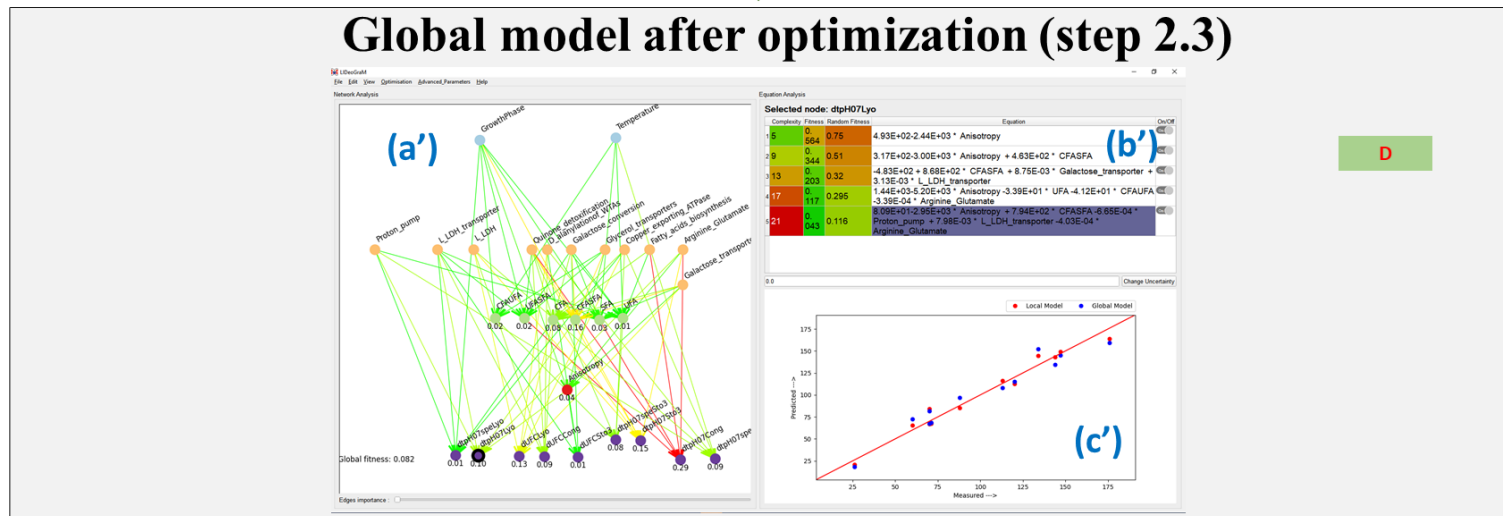
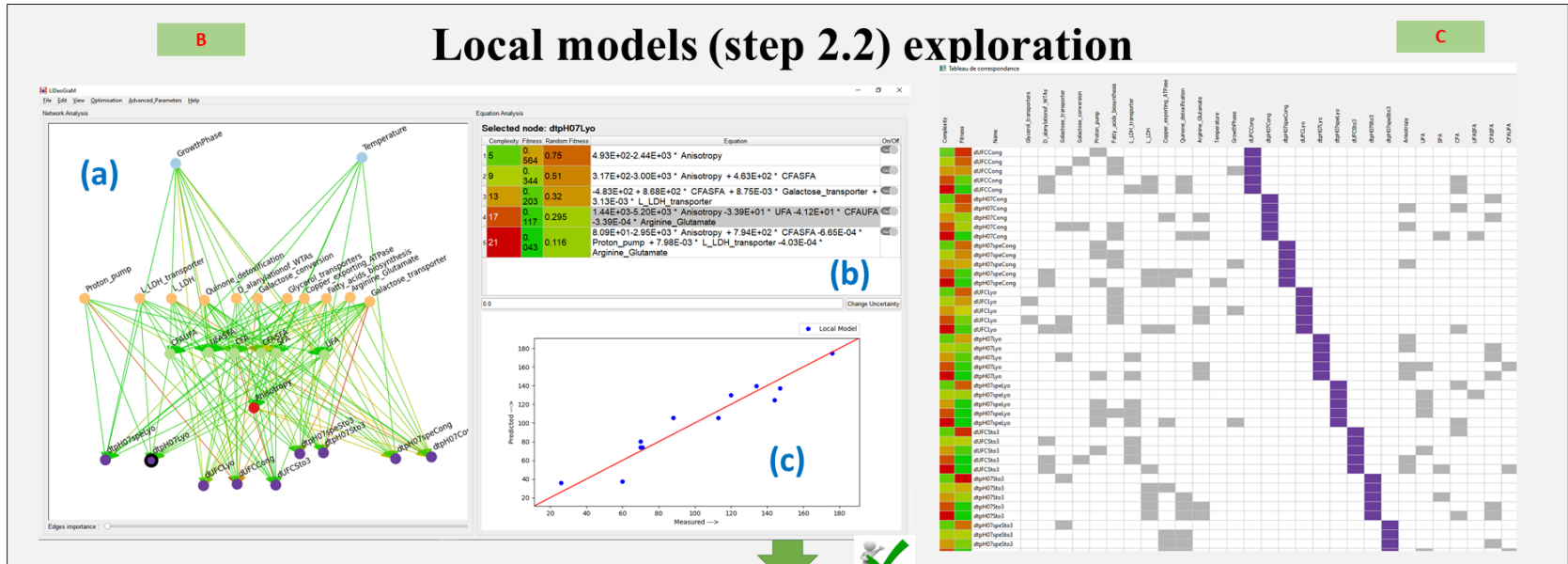
## Local models (step 2.2) exploration

**B**

**C**

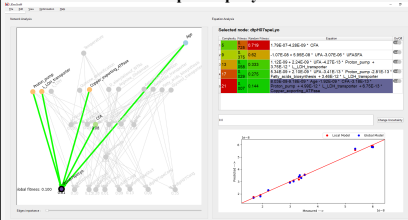


# IMSIE Local exploration >> Global model

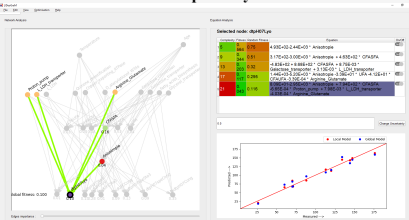


# Bioprocess scale

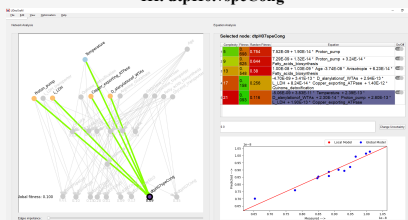
I. dtpH0.7speLyo



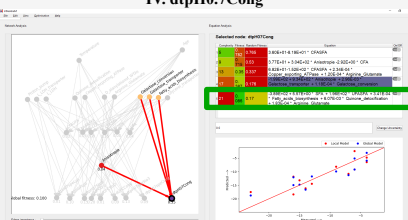
II. dtpH0.7Lyo



III. dtpH0.7speCong

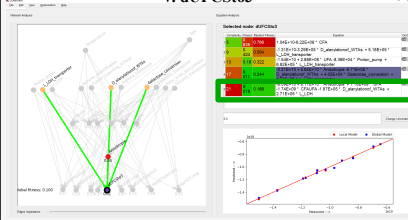


IV. dtpH0.7Cong

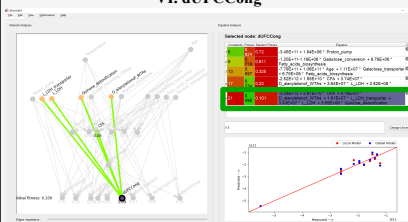


# Population scale

V. dUFCSto3

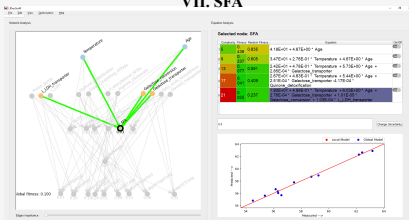


VI. dUFCCong

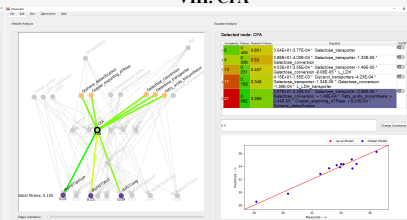


# Cellular scale

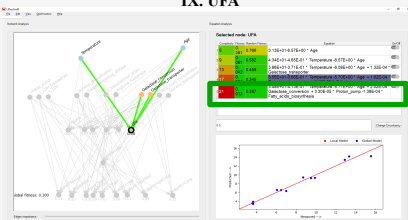
VII. SFA



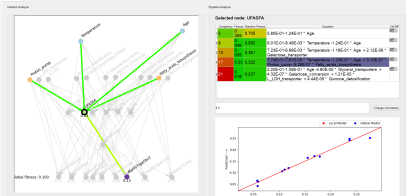
VIII. CFA



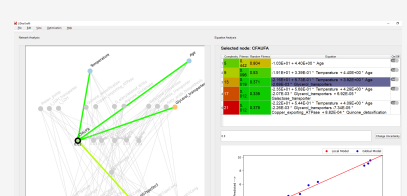
IX. UFA



X. UFA/SFA



XI. CFA/UFA

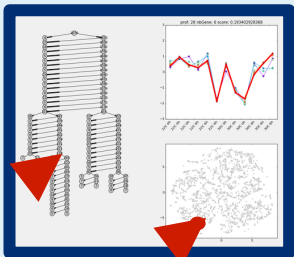


The proof of concept validated !

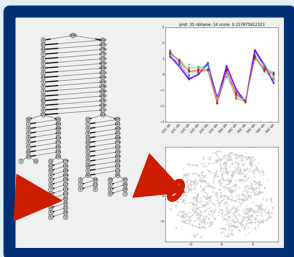




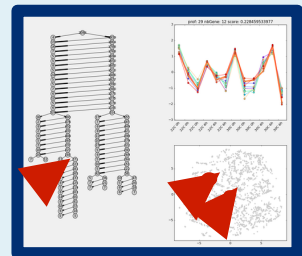
**L-lactate dehydrogenase & L-lactate transporter gene cluster**



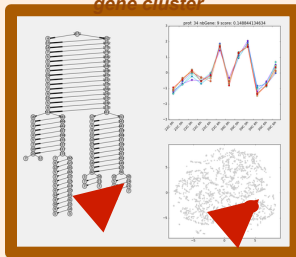
**F<sub>0</sub>F<sub>1</sub> ATPase proton pump gene cluster**



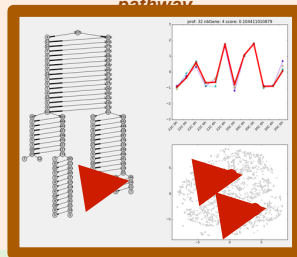
**Fatty acids biosynthesis gene cluster**



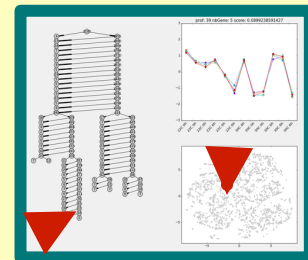
**Copper exporting ATPase gene cluster**



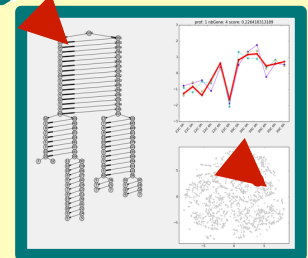
**Quinone detoxification pathway**



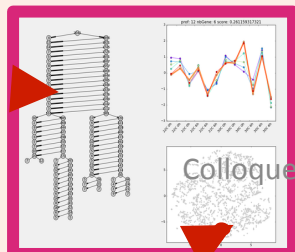
**D-Alanylation of WTAs gene cluster**



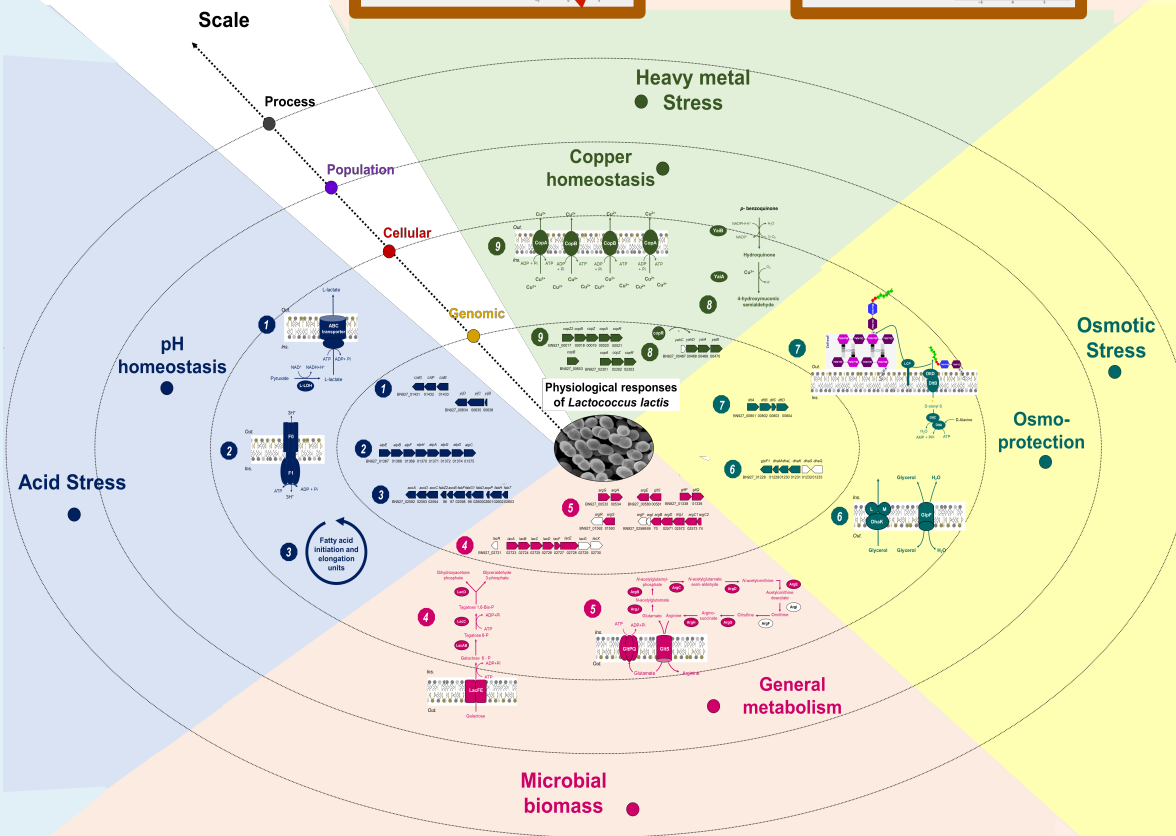
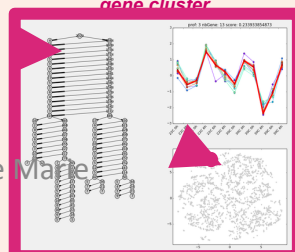
**Glycerol transporter gene cluster**



**Galactose transporter & conversion gene cluster**



**Arginine / Glutamate metabolism gene cluster**



# Biosys Lideogram



Expertise  
Machine learning  
Visualization

- ✓ Taking into account even partial and uncertain data.
- ✓ Integrate the explicit graphic description expressed by the experts.
- ✓ Integrate the cognitive pathways described by experts and accompany its formalization.
- ✓ Integrate the local know-how of the experts in a more multiscale view thanks to expert/machine interaction and exploration.

# Merci pour votre attention

