

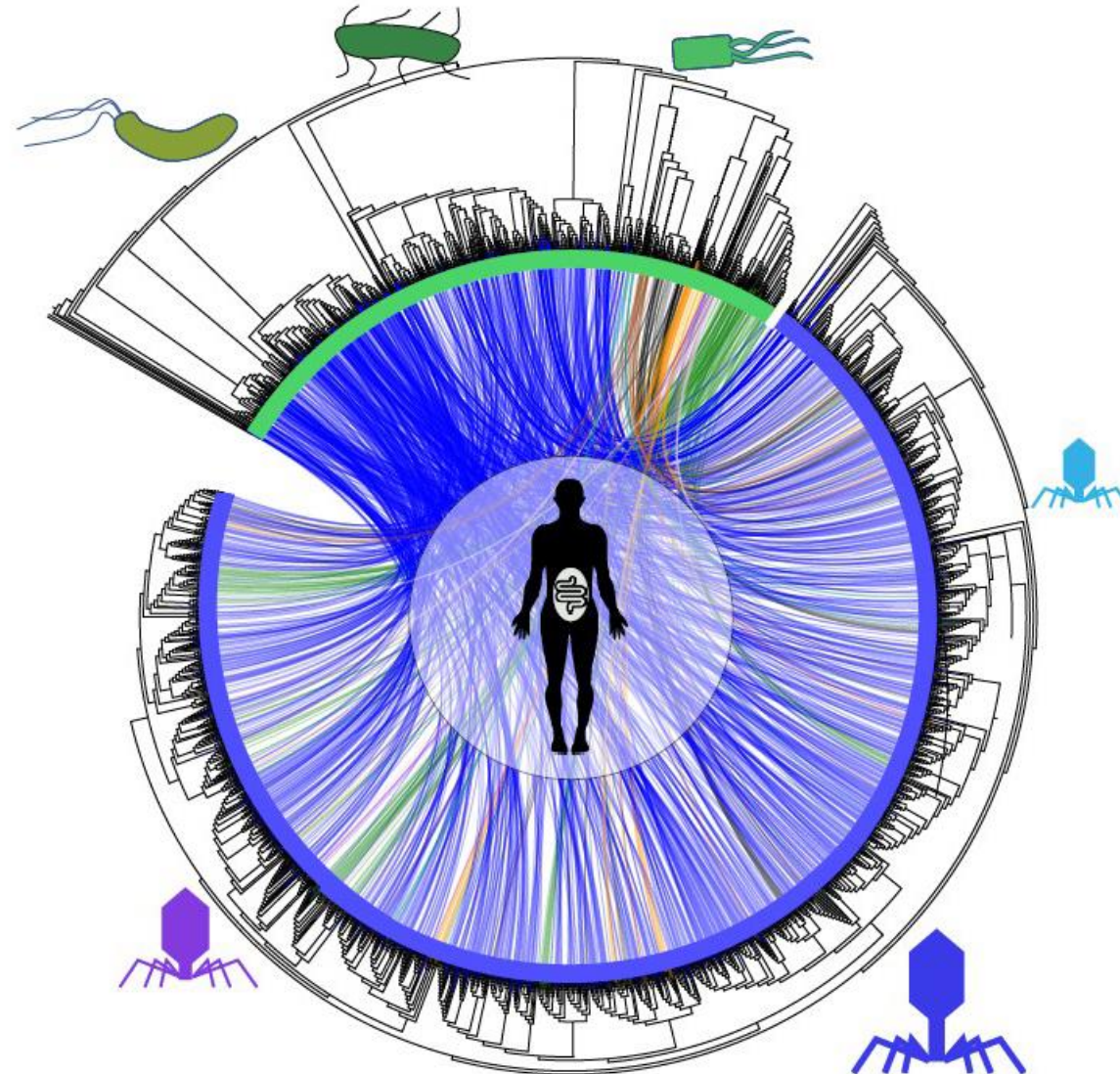
WORKSHOP BIOCONNECT

Introduction to mathematical modeling tools
for microbial interactions
A digital toolbox



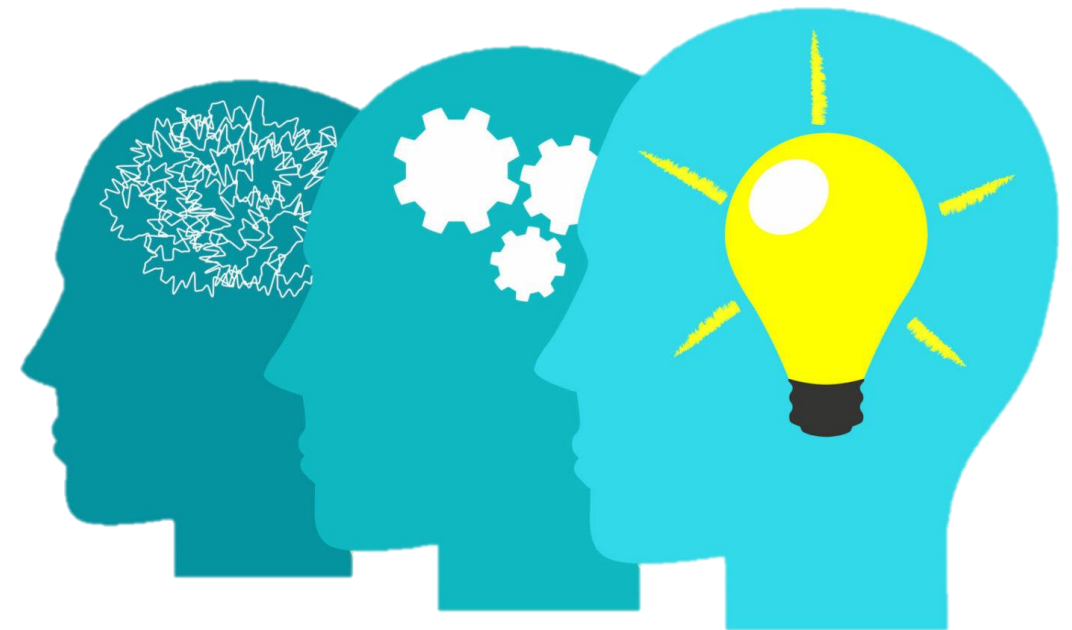
Arnaud COUTU

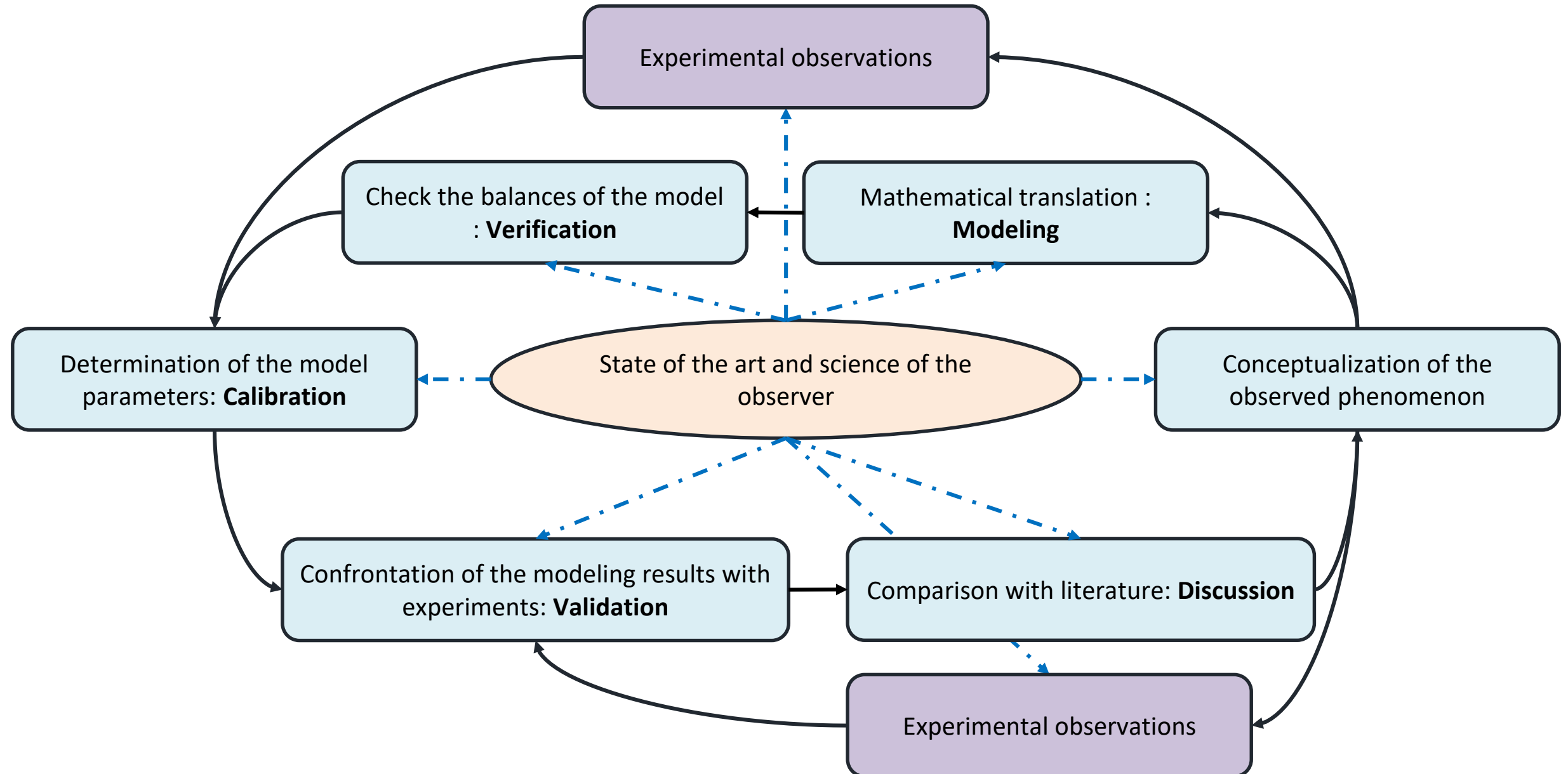
- 1. Definition and Goals**
- 2. Methodology**
- 3. Theoretical approach**
- 4. Stochastic approach**
- 5. Conclusions**



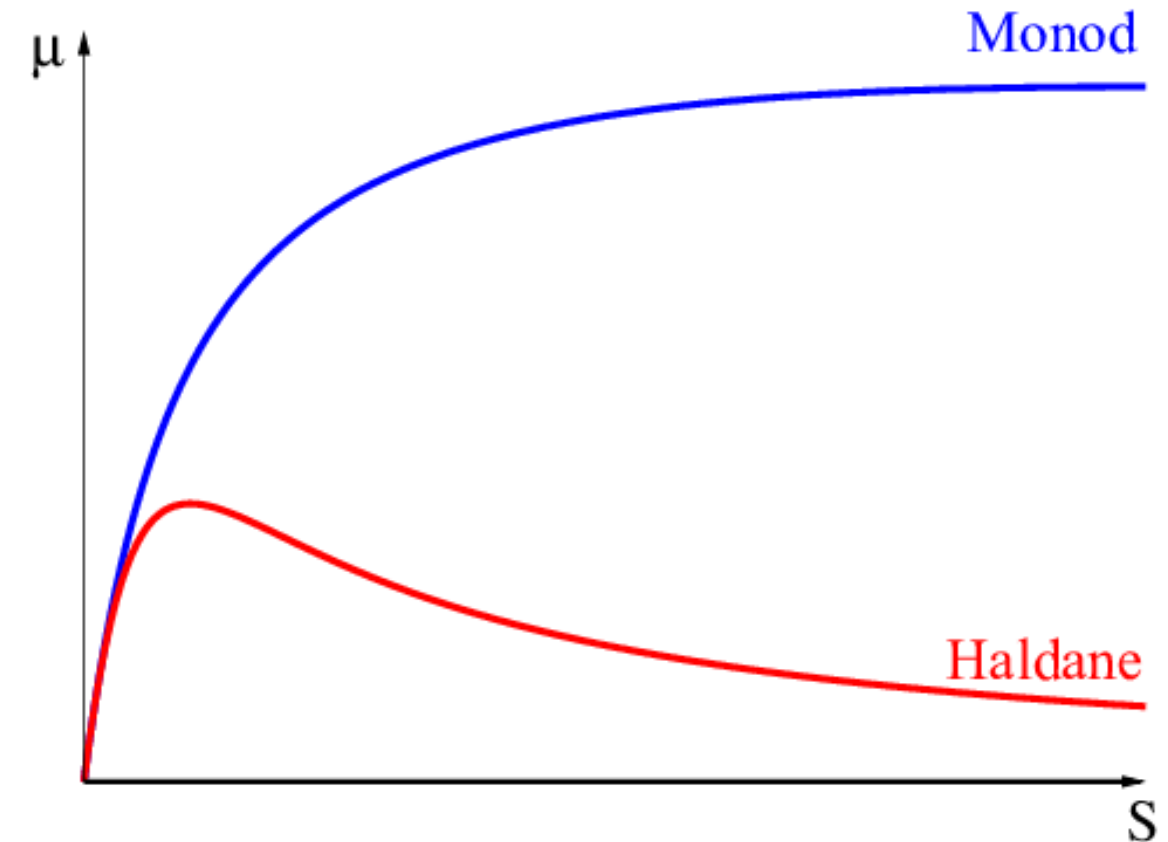
What is modeling ?

- **Represents the biological kinetics and physical behavior**
- **Main goals :**
 - **Quantifying and simulate a system**
 - **Understanding of the phenomenon**
 - **Prediction and Control tools**





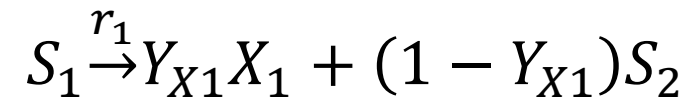
- **First order kinetics**
- **Very easy to implement**
- **No consideration of inhibition phenomena**
- **Monod kinetics**
- **growth limiting factor**
- **Haldane kinetics**
- **Inhibition parameter**
- **Units : $\text{mol.g}_{\text{DW}}^{-1} / \text{COD.g}_{\text{DW}}^{-1}$**



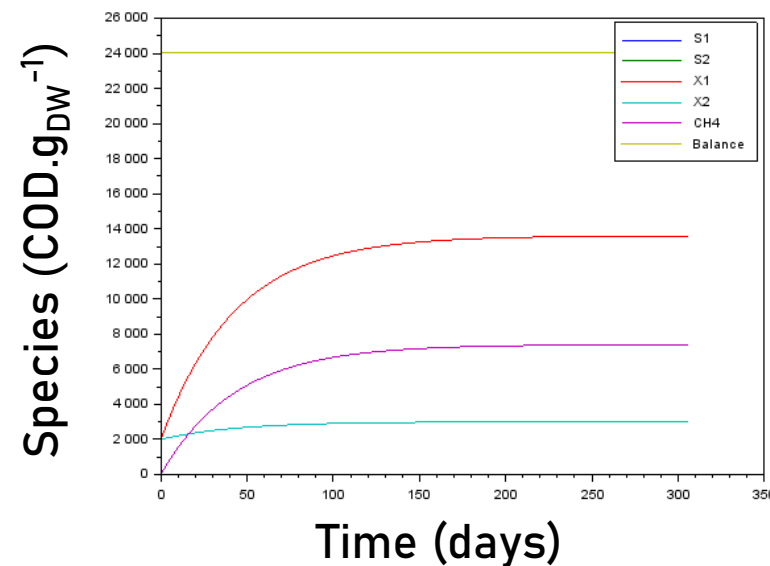
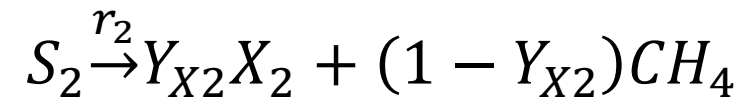
Example: biomass population modeling

- **Anaerobic digestion modeling in a cow stomach**

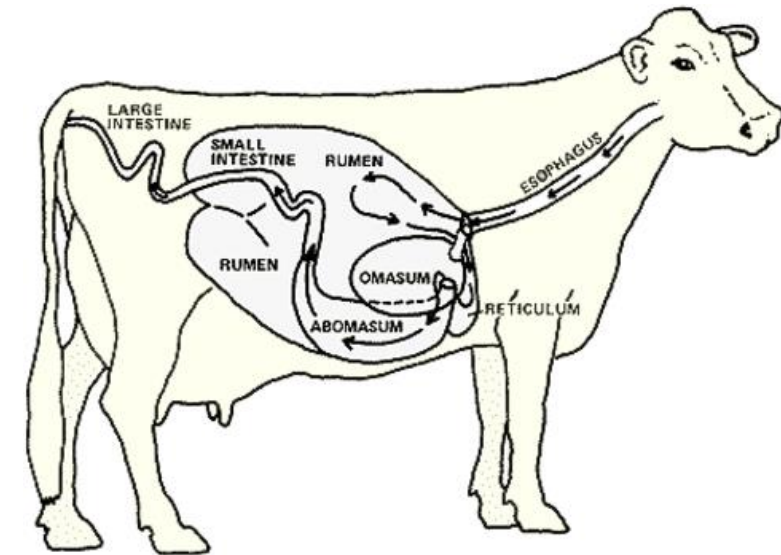
- **Acidogenesis**



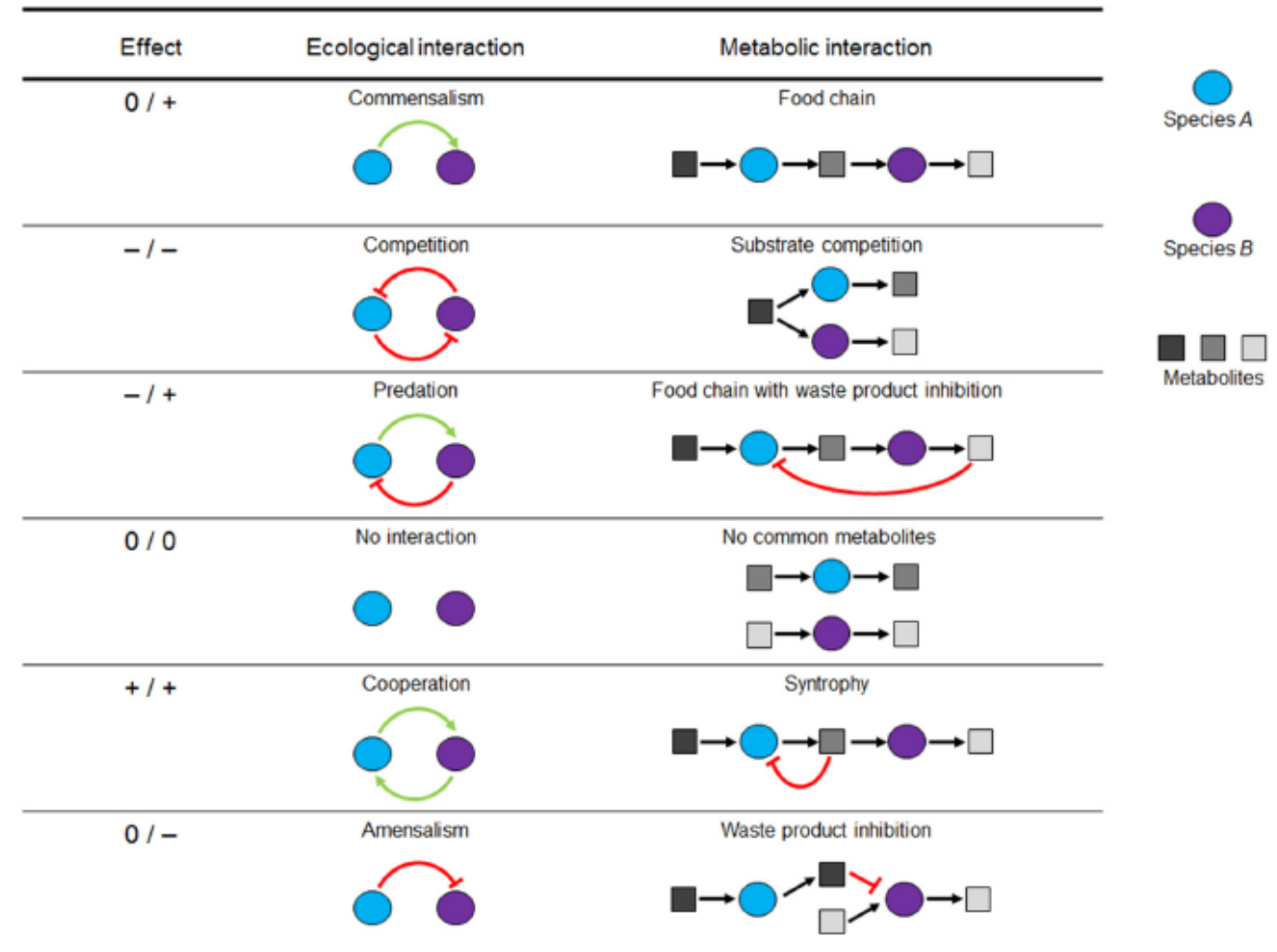
- **Methanogenesis**



$$\frac{dX_1}{dt} = Y_{X1}r_1(t) \quad \text{Monod kinetics}$$
$$\frac{dX_2}{dt} = Y_{X2}r_2(t) \quad \text{Haldane kinetics}$$



- **Physico-chemical balances**
- **Ecological interactions**
- **Metabolic interactions**
- **Hydrodynamics**
- **Biomass mortality**
- **Etc.**



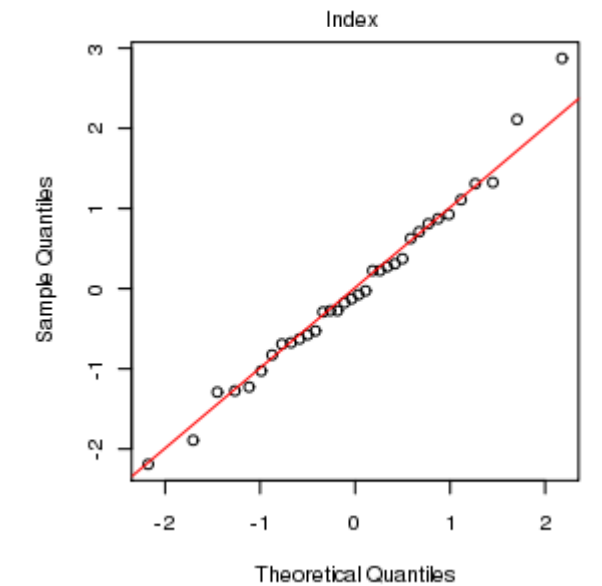
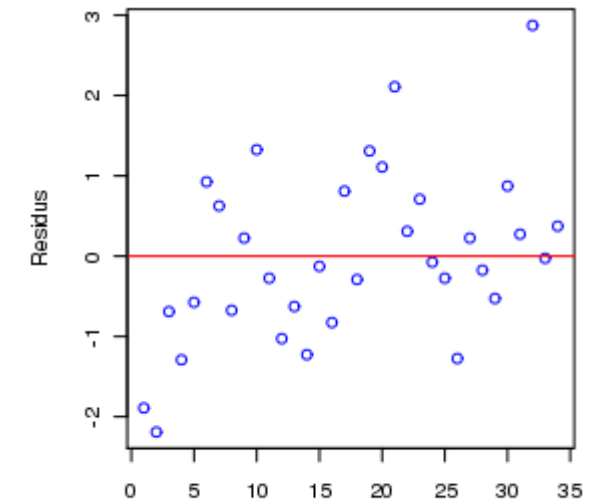
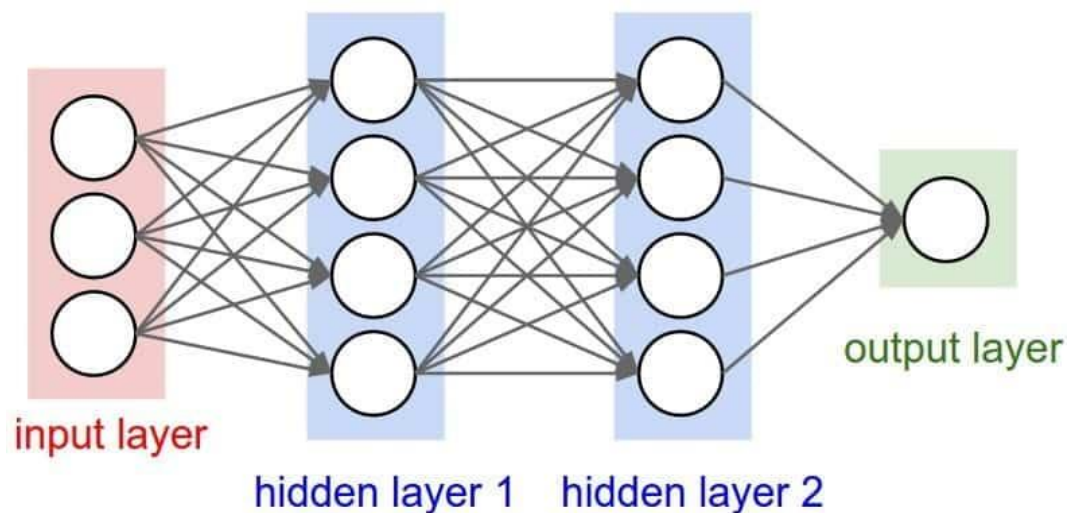


- Efficient in understanding the phenomenon
- Good tool to simulate and monitoring the phenomenon studied

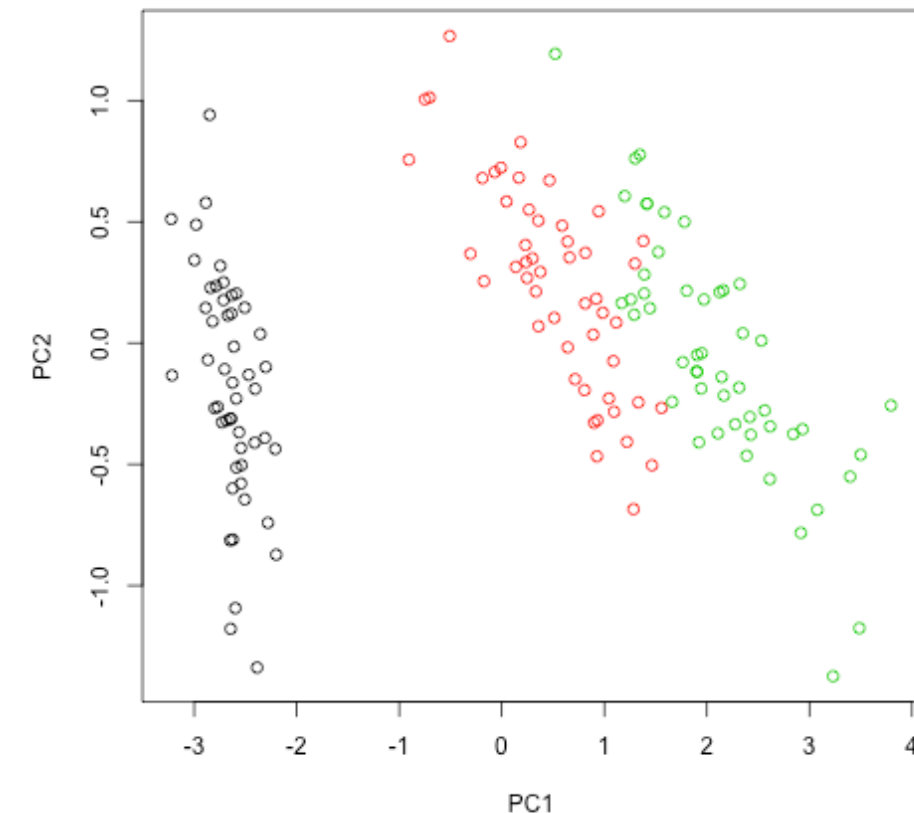


- Modeling could be very complex
- Sometimes kinetics parameters are not identifiable

- **Describe the random variations of the studied phenomena**
- **Numerous modeling are used in the literature**
 - **Linear modeling (linear regression, analysis of variance)**
 - **Non-linear modeling (GAM, neural networks)**



- **Ensure there is no unnecessary or redundant variables**
- **Identify links and correlations between variables**
- **Different methods :**
 - **Principal component analysis (PCA)**
 - **Multiple correspondances analysis (MCA)**
 - **Etc.**





- **Provides robust and repeatable results**
- **It is not necessary to have a deep understanding of the phenomenon**
- **Data analysis provides supplementary contents for scientific studies**



- **It could be difficult to link results and understanding**
- **Data cleansing and analysis are unavoidable preliminary steps**
- **The data set must be large enough to have significant results**

- **A vector of potential for research and industry**
- **Actually modeling is a choice between understanding and robustness**
- **One of the main challenges of tomorrow is the marriage between theoretical and stochastic methods to describe complex phenomena with great results and understanding of the phenomenon**

Thank you for your attention

