

From Genes to Growth Regulation: Towards a Theory of Cellular Economy

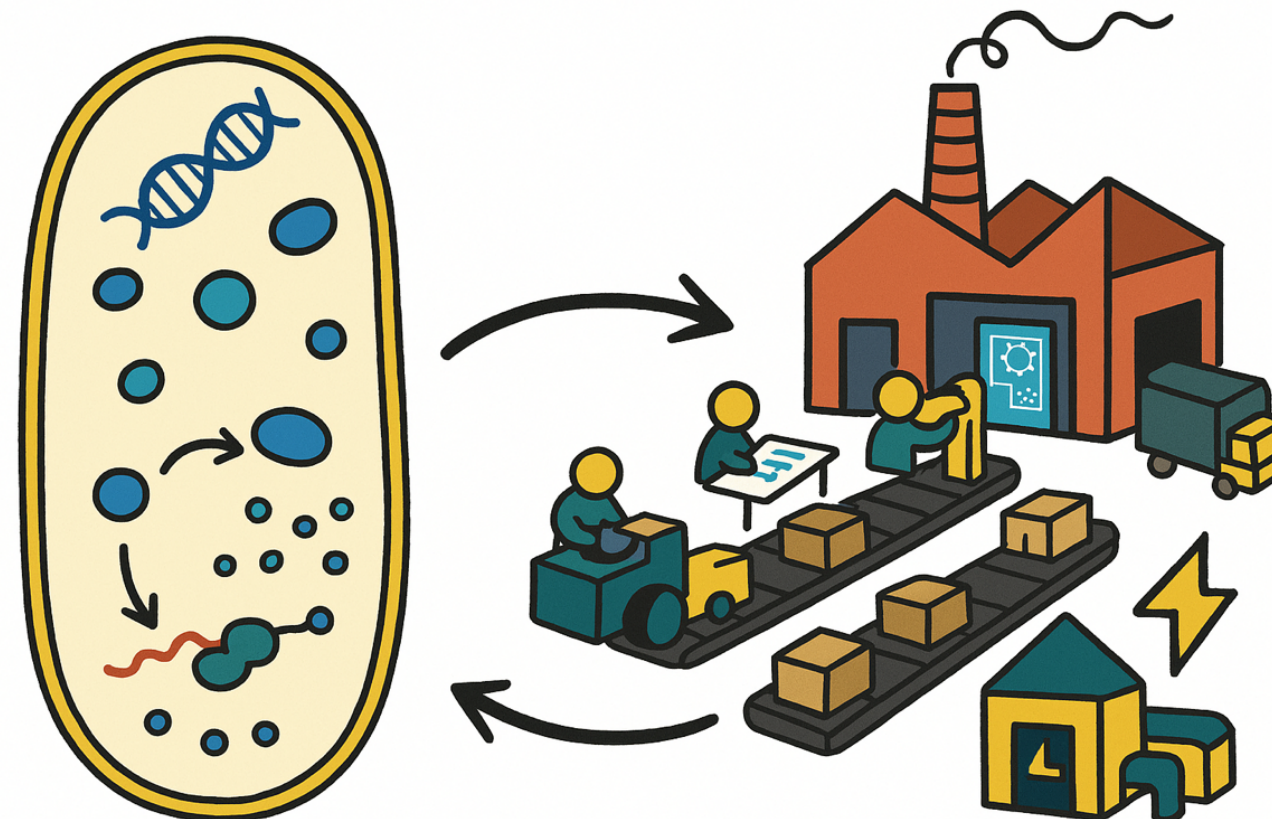
This project is highly interdisciplinary, at the interface of statistical physics, biophysics and quantitative cell physiology.

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We are part of the *Multiscale Biophysical Modeling* team at the Centre de Biologie Structurale (CBS) in Montpellier, CNRS, INSERM, and Université de Montpellier.

General Context

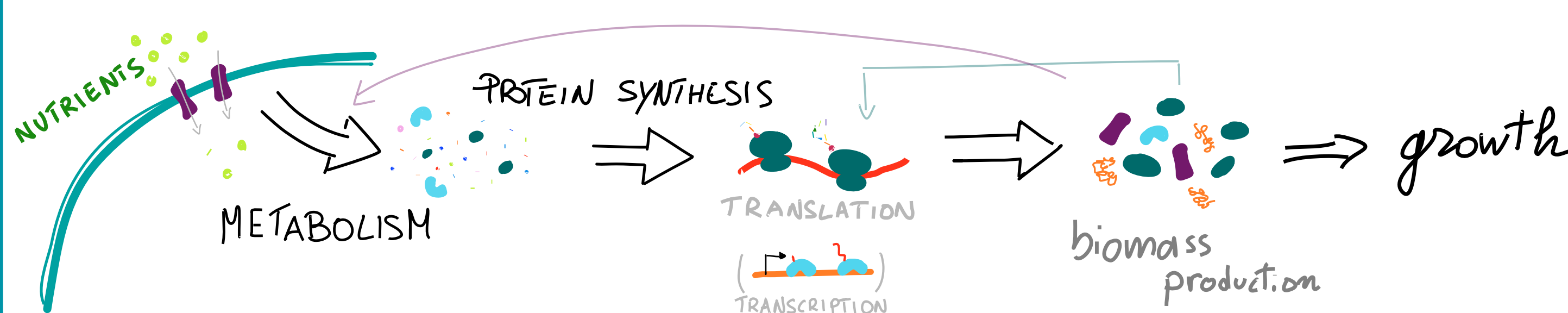
Much like a macroeconomy must balance investments in infrastructure, labor, and energy to support sustainable growth, **a cell must distribute its limited molecular resources** to maintain the production of essential components **while adapting to external demands**.



In recent years, progress in *quantitative* bacterial physiology has led to the emergence of phenomenological **growth laws**, which quantitatively describe how cells allocate their resources—such as ribosomes, metabolic enzymes, and transport proteins—across different physiological conditions.

The Big Question

We still lack a **unifying quantitative framework** that connects the molecular processes of gene expression to physiological outcomes such as cell size control, biomass production, and growth.



Our goal

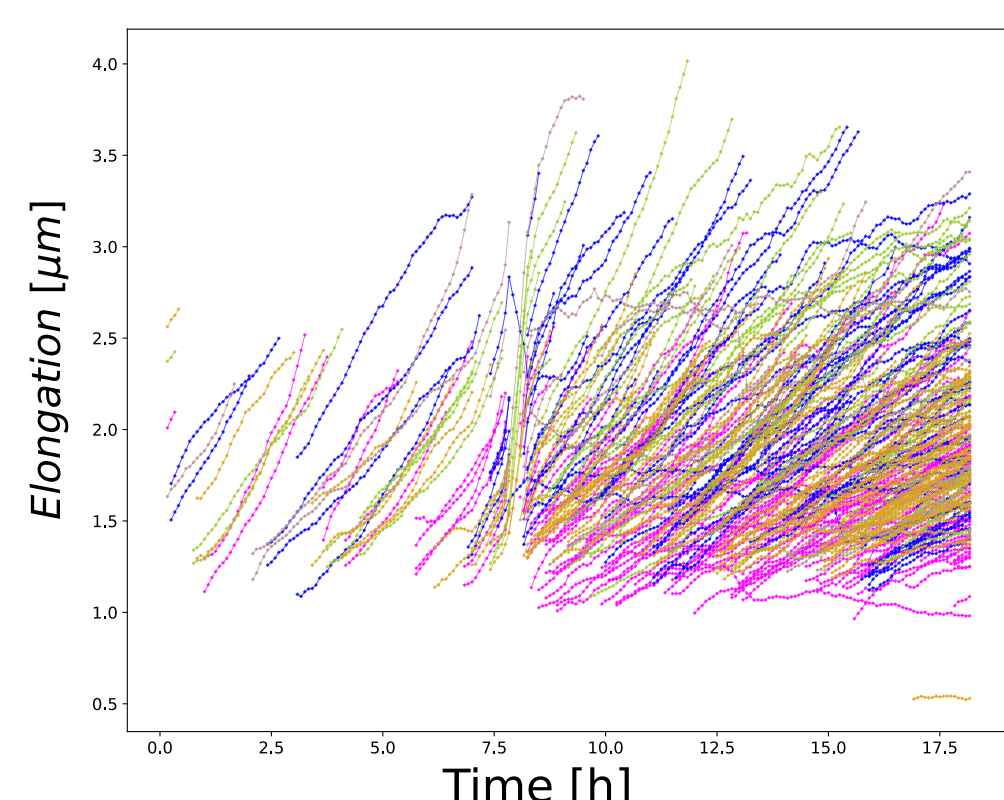
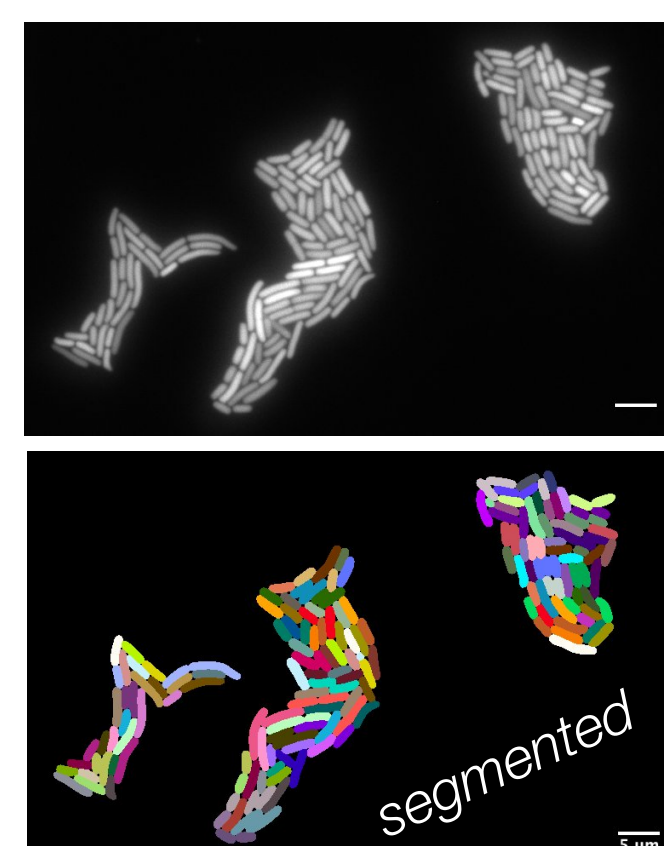
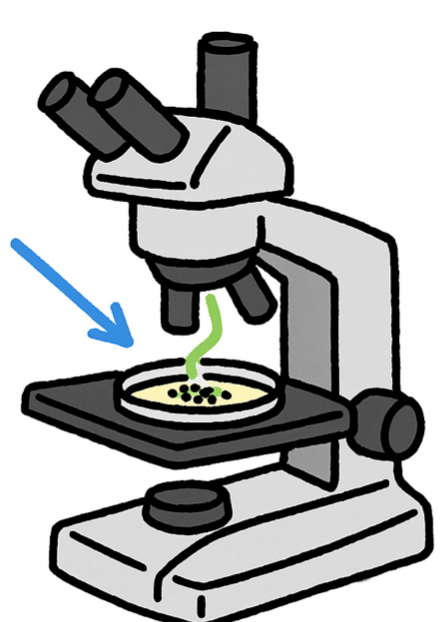
We aim to go beyond phenomenological descriptions by developing **mechanistic models** that link gene expression, cytoplasm organisation, cell volume regulation, and growth rate from first (biophysics) principles. *The goal is to establish a quantitative theory of cell physiology*, and validated by **experimental data**. A particular emphasis will be placed on understanding *how cells adapt when perturbed*—for example, by antibiotic treatment, nutrient shifts,...

What is our approach

The project involves theoretical **modelling**, **experimental work** and **data analysis**.

Bioreactor-based bulk data give population-level insights on growth rate, biomass accumulation, and gene expression under controlled conditions.

Single-cell time-lapse microscopy provide dynamic information on cell growth and gene expression at the individual cell level.

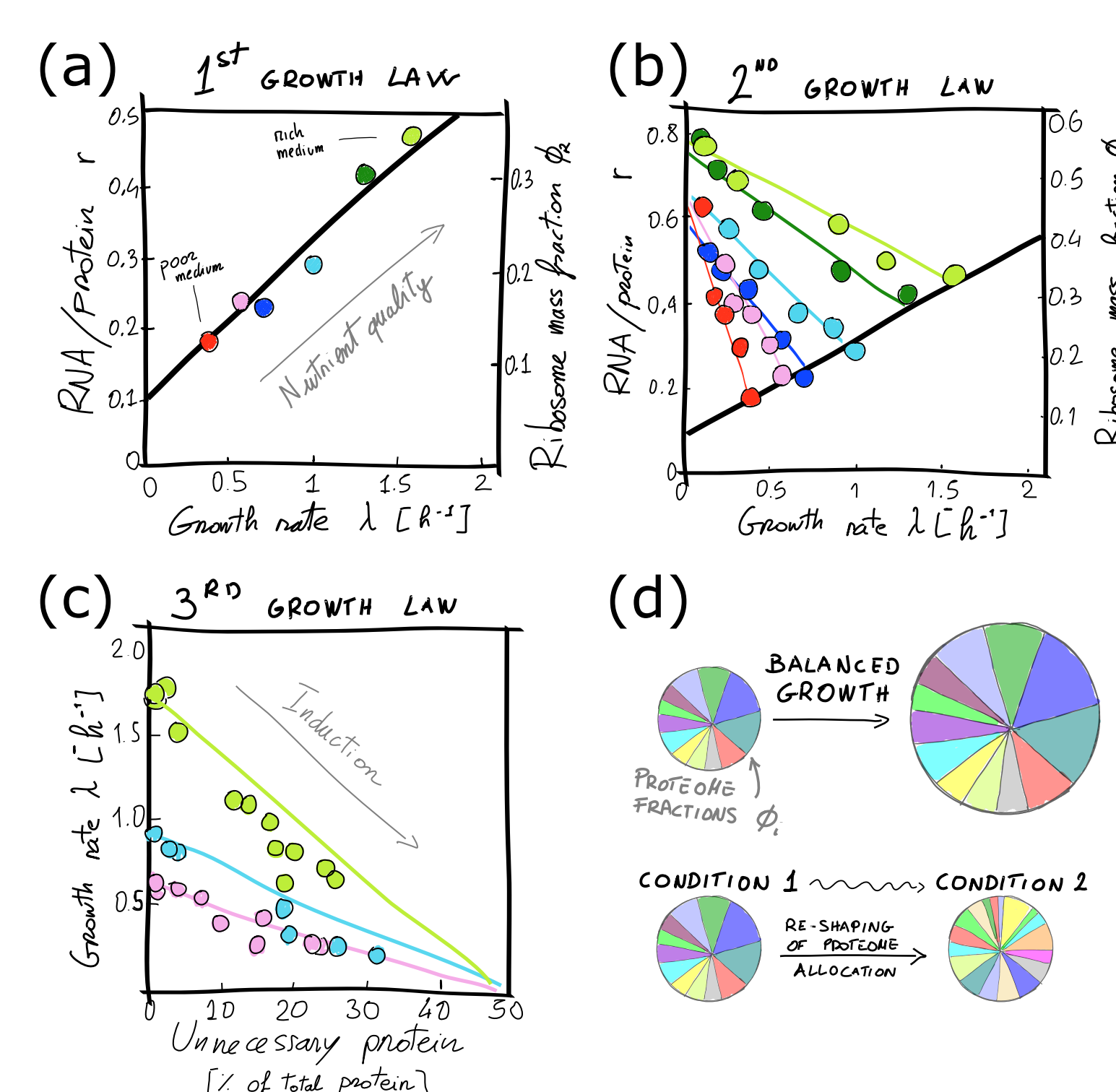


A **theoretical framework**, grounded on stochastic and deterministic models of gene expression and resource allocation, rationalise experimental observations.

If you want to see what's done...

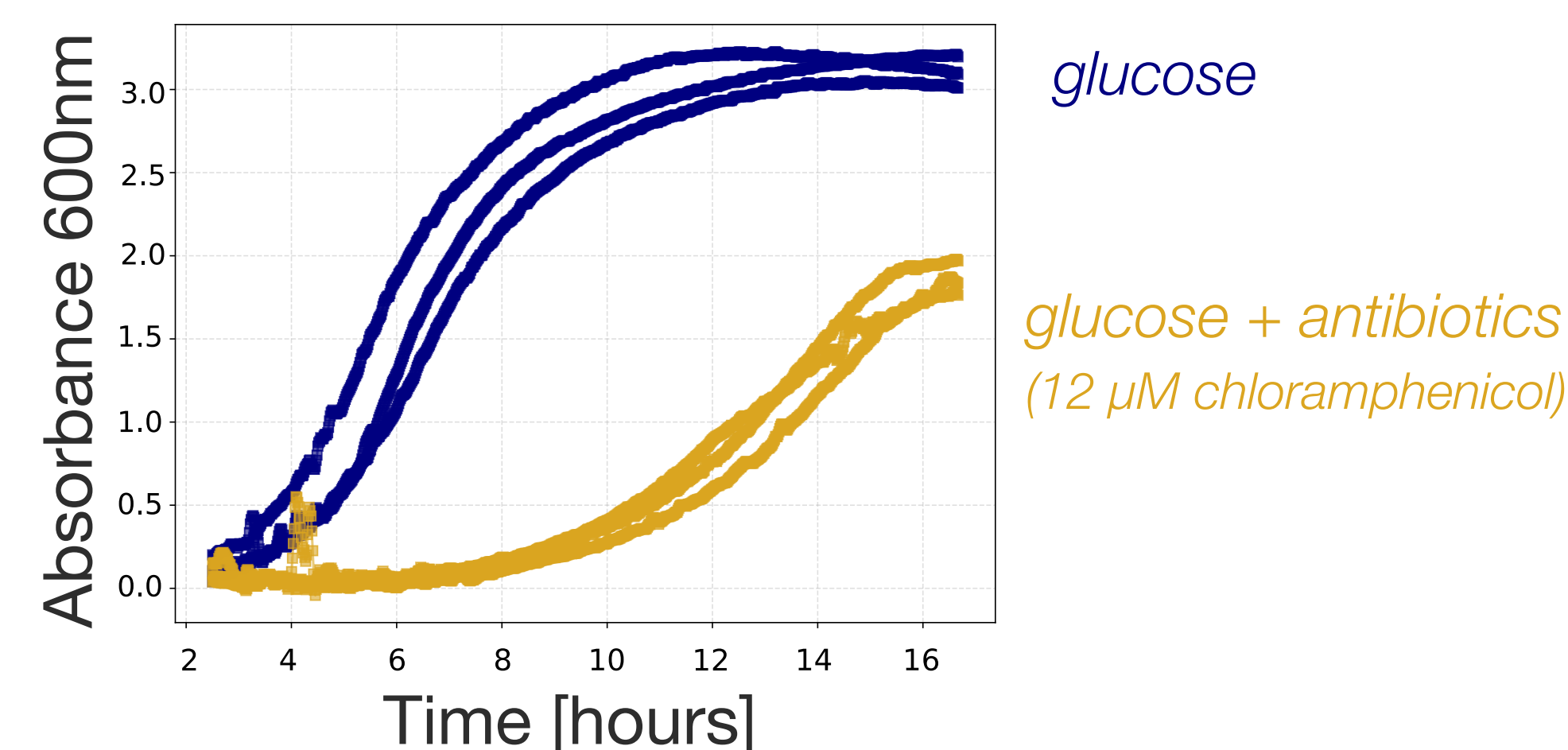
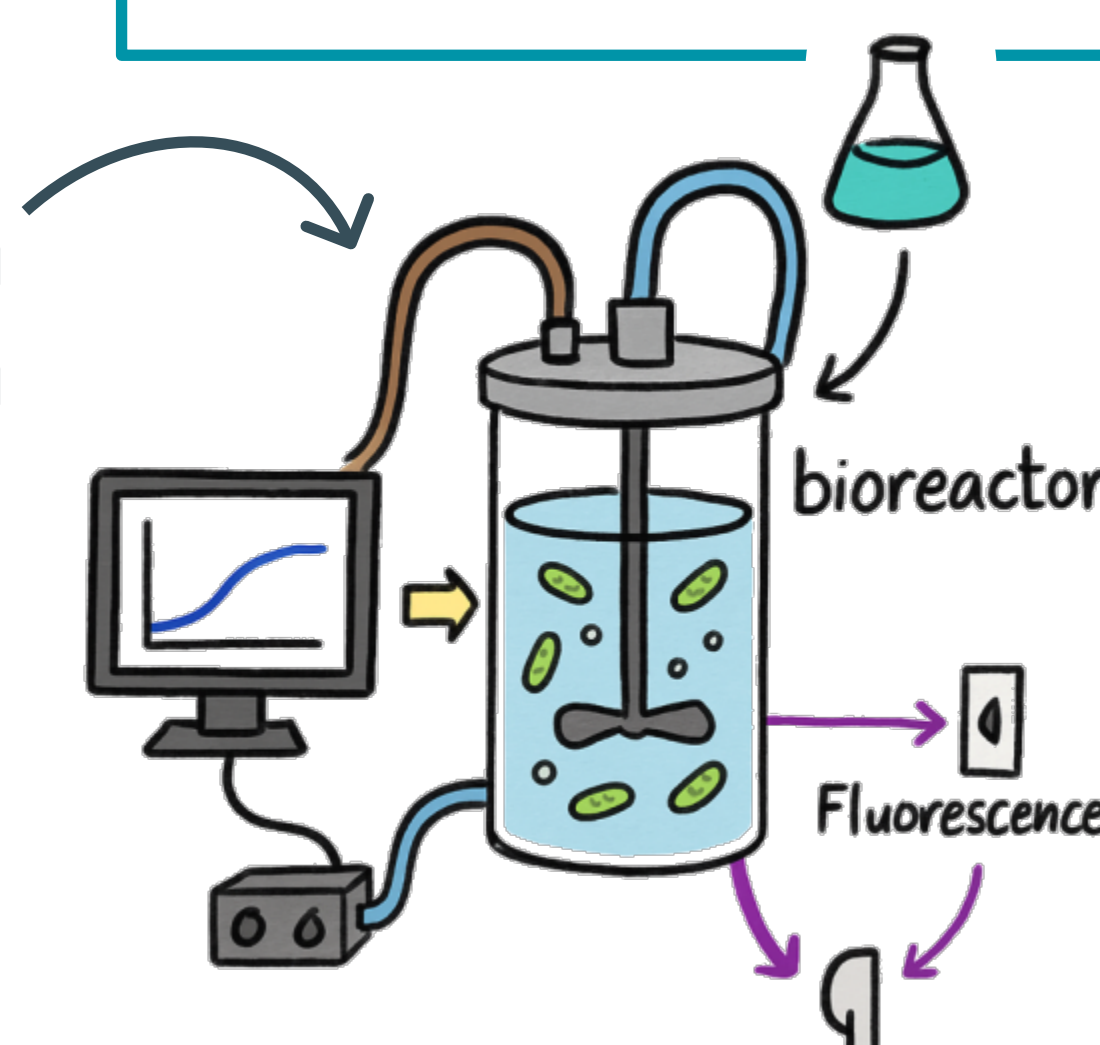
talk to us! The literature is vast, people are trying to formalise universal laws relating cell growth and macromolecular composition.

You can also check out our recent preprint/review:
The Hands-On Growth Laws Theory Cookbook, Droghetti et al. [arXiv:2507.19194]



Who we look for

We look forward working with a **rigorous** student who is **motivated** to *tackle this problem from A to Z*, discussing it with us, developing the theoretical and experimental setups, analyse the data and interpret the results. A background in math/physics, programming experience, are a plus. We can adapt the project on the candidate profile (more experiments, more theory,...) but both aspects are required.



These models will be tested and refined using data obtained from *Escherichia coli* (generated in our lab) and yeast (*Saccharomyces cerevisiae*, in collaboration).

More about us

If you want to know more: (i) do not hesitate to contact us; (ii) check <https://lciandrini.github.io> for research lines and publications; (iii) ask people who previously worked with us.