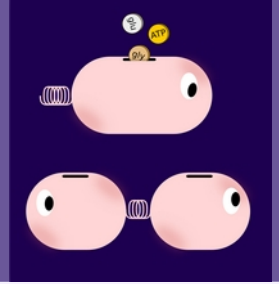
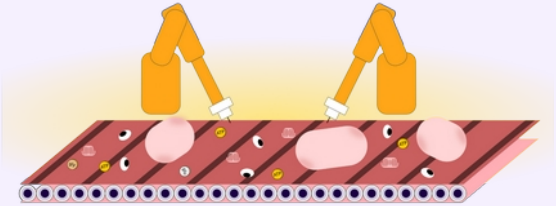
Economic Principles in Cell Physiology

Paris, July 4-6, 2022



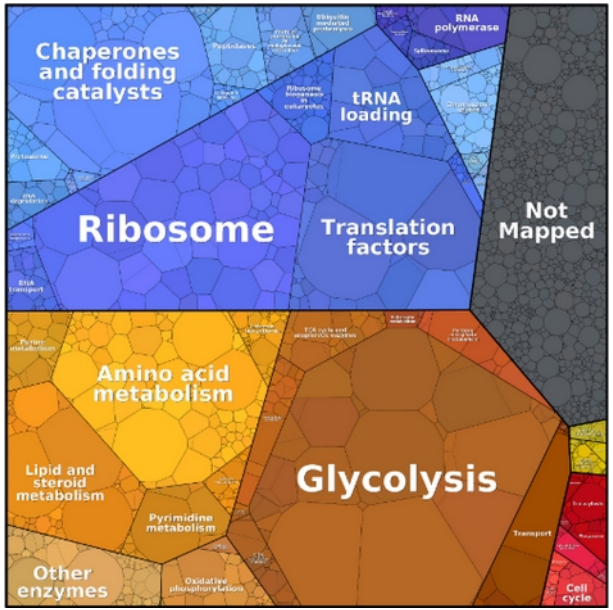
Exploring the economy of the cell

Wolfram Liebermeister and many others

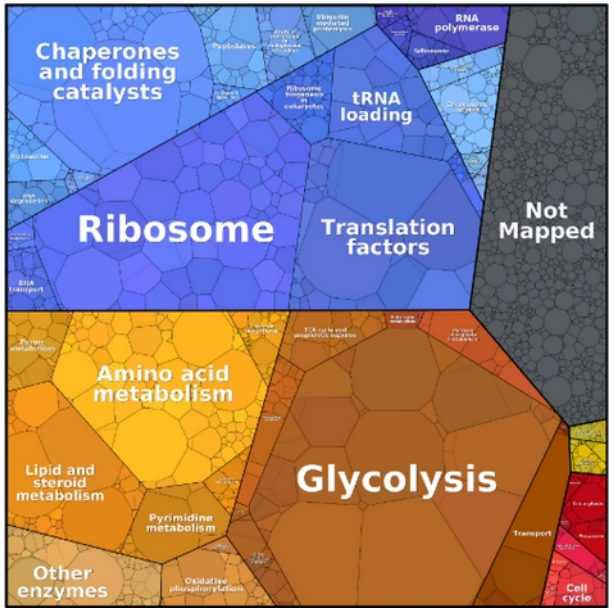


LEARNING PLANET INSTITUTE

The economy of the cell



The economy of the cell



How are protein (and other) resources allocated?

Cellular economics (the way we understand it) = resource allocation + scheduling!

Our book project on “Economic Principles in Cell Biology”

“Economic principles in cell biology”

- Optimality principles have a long tradition in biology (and of course, physics)
- “Resource allocation”: advances in the last decades, but the community is small

Idea of a textbook

- “Metabolites” special issue: could we use this to write a textbook?
- Could we write a book independently?
- Can we get everyone on board and write a book before others do this commercially?
- Started collecting and sorting topics and discussing with colleagues

First discussions

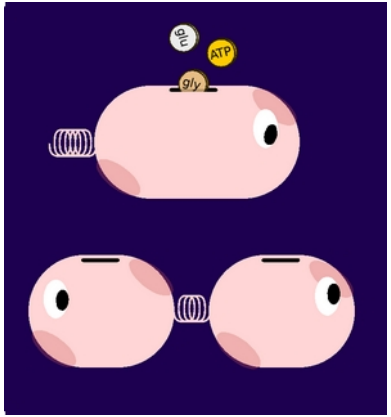
- First, hesitations: is the field mature enough?
- How could we define the topic?
- What could be the audience?

Our book project on “Economic Principles in Cell Biology”

Our plan

Write a book for researchers and students that describes the economics of cells from different angles.

The book will be an open resource for learning and teaching, non-commercial and freewritten by and for the community.



Your contribution

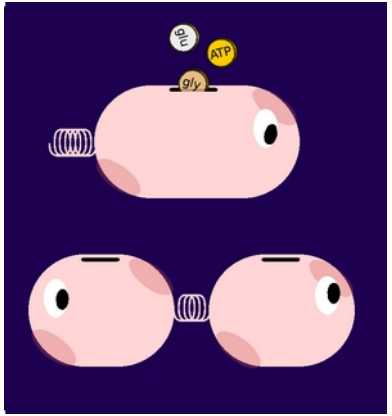
Everybody is welcome to join!

To propose a chapter or to contribute to writing, editing or graphic design, please get in touch.

principlescellphysiology.org/book.html

The Forum “Economic principles in cell physiology”

The Forum “Economic Principles in Cell Physiology” is a place for discussions in the field of cell biology and mathematical modelling, organised by an open group of researchers.



We meet every month to discuss fundamental questions in our field.
Dates: 1st Tuesday of each month, 5:30 pm CET

Our group is open to researchers at any stage of their career.
Students, junior faculty, advanced researchers, professors emeriti: please feel free and welcome to join!

https://principlescellphysiology.org

“Principles in Cell Physiology” Scholars Group

- A group of young scientists (students, PhD students, post docs) in the field of cell physiology, systems biology, cell communities or similar.
- We provide a safe space to share or ask anything related to science
  (could also be on the logistical side: finding post doc postion, sharing workshops and confrences, etc.).
- Monthly discussion: every second Monday of the month.
  Each month a different member of the group organizes the discussion/talk.

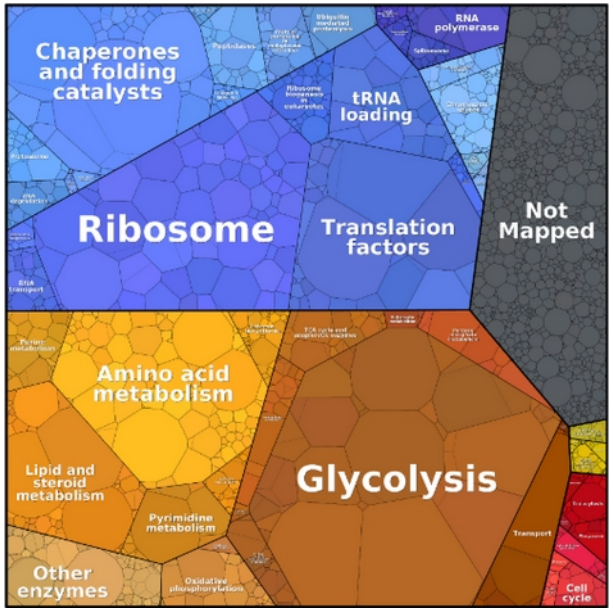
Contact

Website - https://principlescellphysiology.org/scholars.html
Slack channel - PlCPhysiology_scholars

Niccolo Totis - niccolo.totis@kuleuven.be

Ohad Golan – golan@imsb.biol.ethz.ch

The economy of the cell

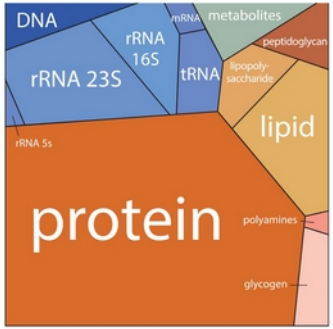


How are protein (and other) resources allocated?

Cellular economics (the way we understand it) = resource allocation + scheduling!

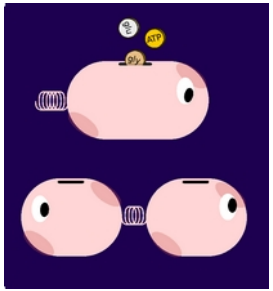
How do cells function, and how can we describe this?

What makes up a cell?



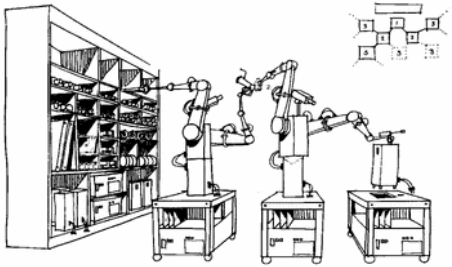
How does metabolism function?

How can we understand economic or “optimal” cells?

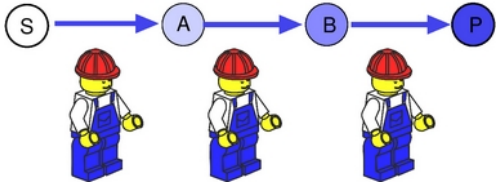


How are metabolic strategies shaped by resource allocation?

Balanced growth:
What needs to be produced, in what proportions?

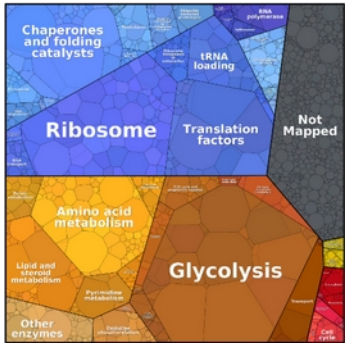


How to realise desired metabolic fluxes with minimal enzyme amounts?



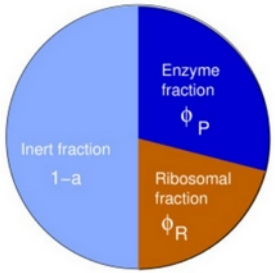
How to predict metabolic fluxes?

What is the optimal metabolic state of a cell?

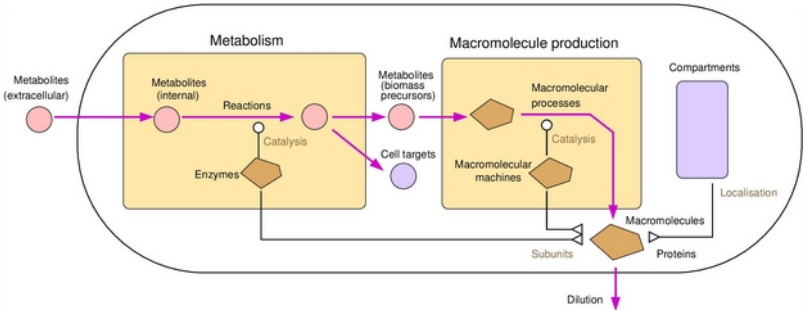


How is cells' physiology shaped by resource allocation?

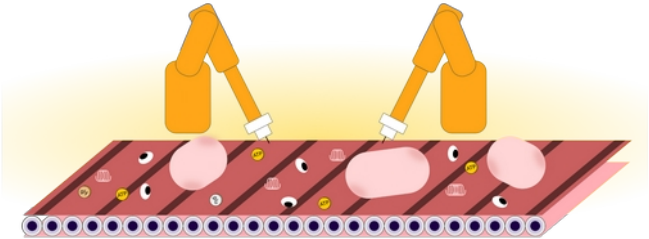
How are resources allocated between metabolism and protein production?



Resource balance analysis:
How are resources allocated in an entire cell?



Optimal scheduling:
How should cells allocate resources in time?



Outline of the book

Introduction
1. The cell as a factory

Part 1: Cells and metabolism
2. Understanding living cells
3. What makes up a cell?
4. A dynamic picture of metabolism
5. Balanced growth
6. Optimality problems in biology

Part 2: Metabolic models
7. The flux polytope
8. Optimisation on the flux polytope
9. The choice between metabolic pathways
10. Enzyme-efficient metabolic states

Part 3: Cell models
11. Coarse grained models of cellular growth
12. Large detailed cell models
13. Costs and benefits of protein expression

Part 4: Dynamics
14. Optimal behavior in time
15. Optimal regulation
16. Return on investment in cellular metabolism

Part 5: Cell populations and evolution
17. Metabolic diversity in cell populations
18. Cell strategies under uncertainty
19. Evolution, fitness, and optimality

Our summer school

Monday July 4	Tuesday July 5	Wednesday July 6
Exploring the economy of the cell (10 am) W. Liebermeister, E. Noor, M. Köbis, O. Golan	**Balanced cell growth** (10 am) Frank Bruggeman	**Self-replicator cell models** (10 am) Ohad Golan
What makes up a cell? (10:45 am) Diana Széliová	**Flux balance analysis** (11 am) Steffen Waldherr	**Resource allocation models** (11 am) Anne Goelzer and W. Liebermeister
Lunch break (noon)	Lunch break (noon)	Lunch break (noon)
Get-together (1 pm)	**How to write a book that is useful to the community** (1 pm) Discussion with Ron Milo	**Plans and collaborations** (1 pm)
Optimality problems in cells (2 pm) Markus Köbis and W. Liebermeister	**Cost of metabolic pathways** (2 pm) Elad Noor and W. Liebermeister	**Optimal cell behavior in time** (2 pm) Hidde de Jong and M. Köbis
Coffee break (3 pm)	Coffee break (3 pm)	
A dynamic view of metabolism (3:30 pm) Orkun Soyer	**Optimal metabolic states** (3:30 pm) Meike Wortel	**Closing discussion** (3 pm) all participants
A guided tour of the LPI (4:30 pm) Cecilia Patitucci and LPI students	**Tutorials/exercises** (4:30 pm) Depending on participants' interests	**Farewell party** (4 pm)

Teachers

Anne Goelzer, INRAE
Diana Széliová, Universität Wien
Elad Noor, Weizmann Institute of Science
Frank Bruggeman, VU Amsterdam
Hidde de Jong, INRIA
Markus Köbis, NTNU Trondheim
Meike Wortel, Universiteit van Amsterdam
Ohad Golan, ETH Zürich
Orkun Soyer, Warwick University
Ron Milo, Weizmann Institute of Science
Steffen Waldherr, KU Leuven
Wolfram Liebermeister, INRAE

Inspired by lectures by Ron Milo that helped shape his book

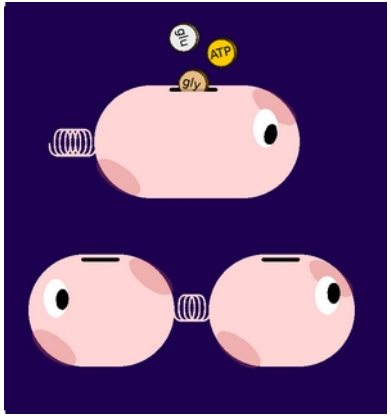
A place to test and improve our ideas for the book, and get feedback from you!

Join our community!

Join us for the Forum meetings!

Join us for the book project!

Let’s build a community!



Practical information

General information

- Course program and general information on our course website
  https://principlescellphysiology.org/summer_school_2022.html
- *-> Practical information -> Program and information for participants*

Book “Cell biology by the Numbers” (Ron Milo’s talk on Tuesday)

- Book website (including free pdf of the draft version):
- http://book.bionumbers.org/

Information about out book project

- An overview and current chapter drafts can be found on our website
- https://principlescellphysiology.org/book.html

General biology / economics / modelling questions

- During the course, please think of questions or topics for our closing discussion

Information for online participants

Sound quality

- The microphones in the room are not great .. if the sound is bad, please let us know!

Chat + camera

- Please write your questions in the chat – a chat moderator will ask them for you
- Microphone and camera should usually be shut off

Recordings

- If you don’t want to be recorded, make sure to shut off your camera + mike!

Troubleshooting

- In case of problems, contact Hidde de Jong via epcp-summer-school-2022@googlegroups.com

Any questions?

Welcome to Paris!

www.pixelstalk.net/paris-wallpapers-hd/

Practical questions

Covid rules

- Please use masks!
- Please self-test or get tested!
- Masks and some self-tests are available

Food

- Lunch from 12:00-13:00
- Food allergy information: ask Cecilia for list of ingredients

Photos

- Photos taken during the course may appear on the web
- If you don't want to appear on photos, please let us know
- Group photo tomorrow at 12:00

Whom to ask stuff

Other questions?

Social events

Today

- Lunch → you can also eat outside
- Get-together in the courtyard (1 pm)
- See the Learning Planet Institute (4:30 pm)
- After the course: walk in the Marais .. we also recommend:
- Bar “Les Nautes”, 1 Quai des Célestins (at the Seine, at the end of Rue Saint Paul)
- Bar in “La petite ceinture”

Tuesday

- Group photo (noon)
- After the course we propose: hang out in “Les Nautes” and go for a walk along the Seine

Wednesday

- Farewell party (4 pm)


Are there any classes you're struggling with?
The bourgeoisie