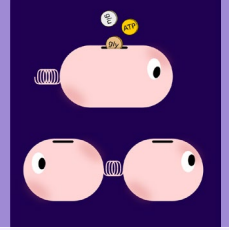
Economic Principles in Cell Biology

Paris, July 08-11, 2024



The economy of the cell

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EURIP LEARNING PLANET INSTITUTE

What do we want to understand?

What do we want to understand?

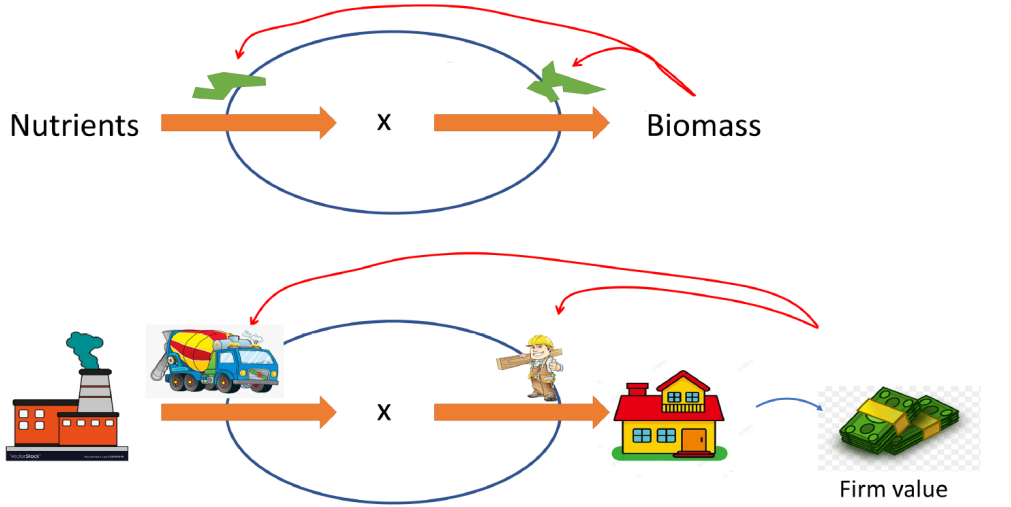
Short answer: Life

What do we want to understand?

Why do cells behave as they do?

- Why do they have certain enzymes?
- Why do they respond to the environment as they do?
- …

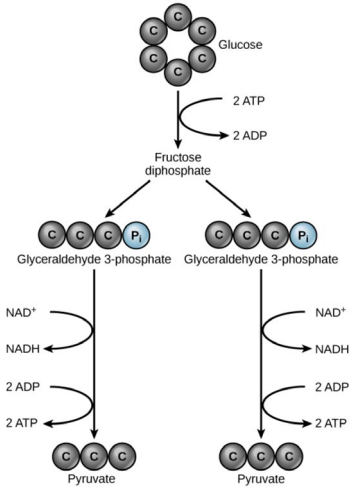
What do we mean with “Economy of the cell”?



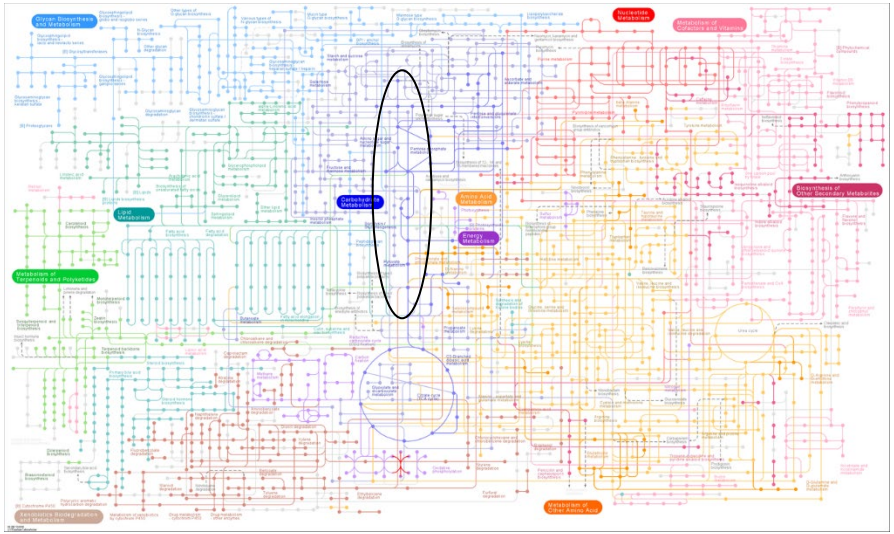
Converting nutrients into biomass with the ‘workers’ that are available.

Figure: Ohad Golan

Cells need food for energy and biomass production



Glycolysis

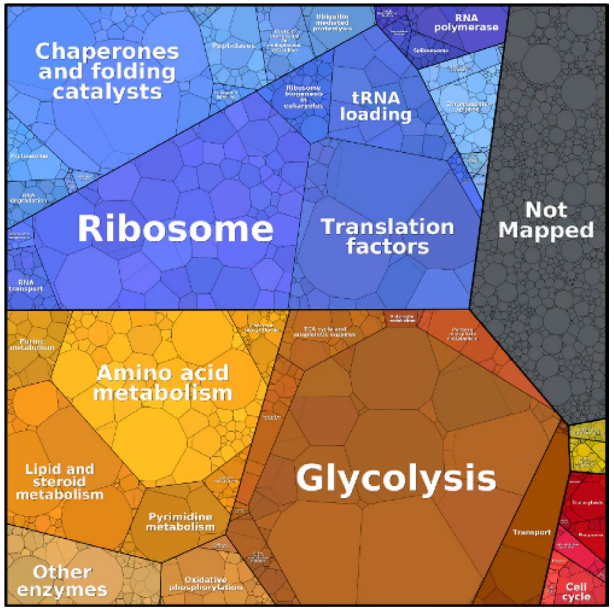


TCA cycle
Amino acid
Production
…

Figure: OpenStax

Two answers to the ‘why question’

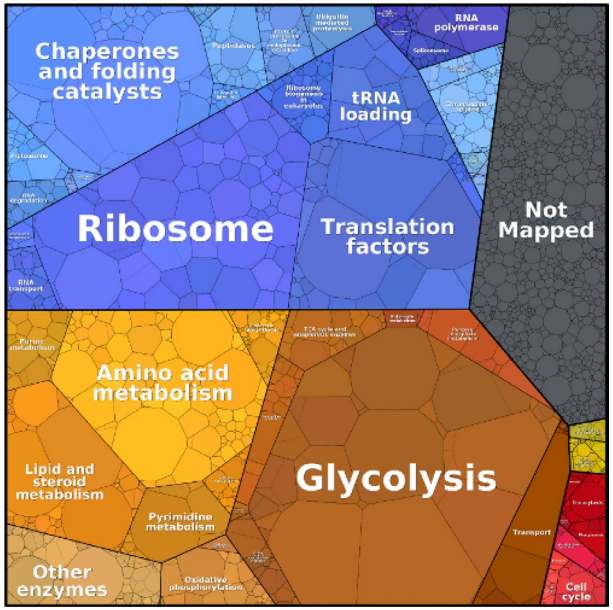
“Why to cells use a large fraction of the proteome for glycolysis?”



Two answers to the ‘why question’

“Why to cells use a large fraction of the proteome for glycolysis?”

1. Because glucose is sensed, a signalling cascade is activated and glycolytic enzymes are produced



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“Why to cells use a large fraction of the proteome for glycolysis?”

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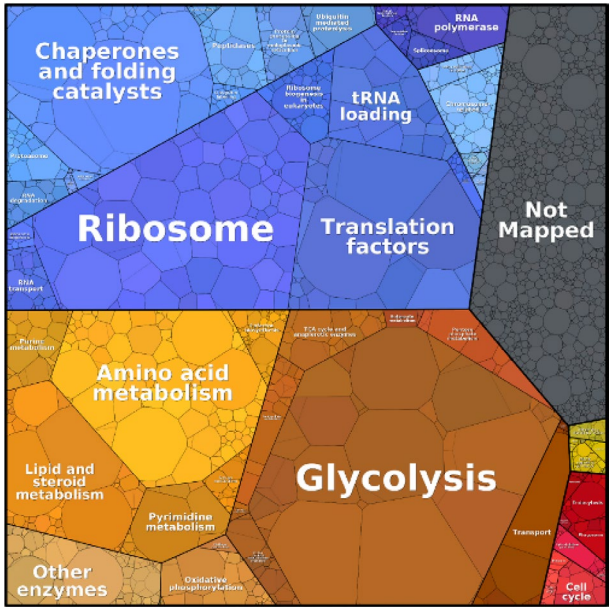
“Proximate explanation”

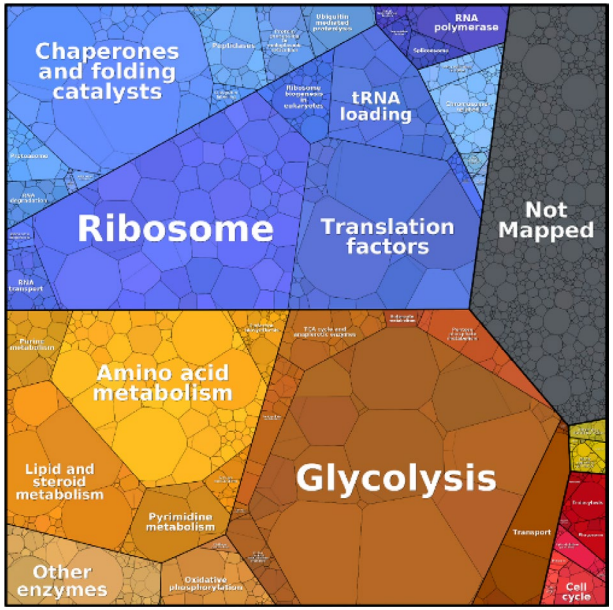


Two answers to the ‘why question’

“Why to cells use a large fraction of the proteome for glycolysis?”

1. Because glucose is sensed, a signalling cascade is activated and glycolytic enzymes are produced
“Proximate explanation”

2. Because if less would be invested in glycolysis, there would not be enough precursors and energy for biomass production, cells would replicate less and be replaces by competitors



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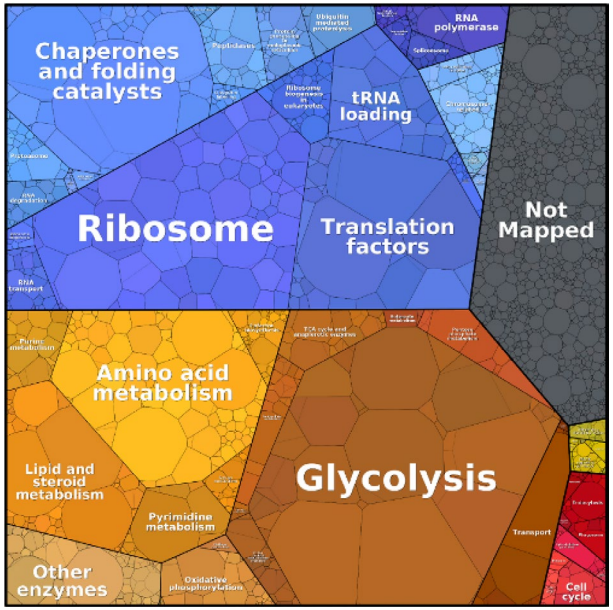
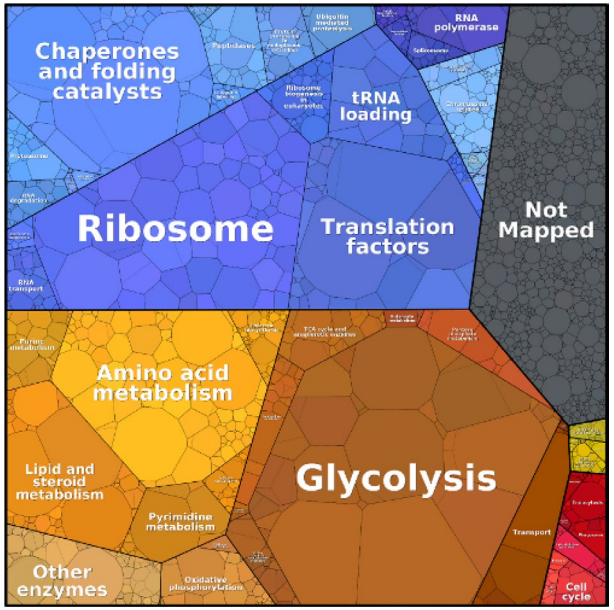
“Evolutionary explanation”



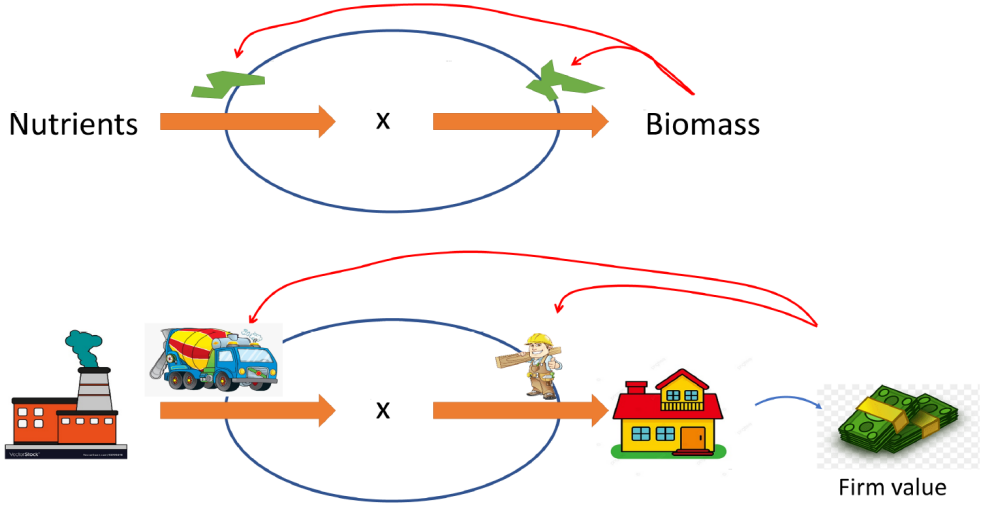
Focus on evolutionary explanation

Assuming that:

1. Genetic variation in the genes coding for enzymes and regulation exists
2. This variation leads to different metabolic phenotypes
3. These metabolic phenotypes are selected in an environment



Economic principles: Constraints, cost and benefit



Constraints:

Costs:

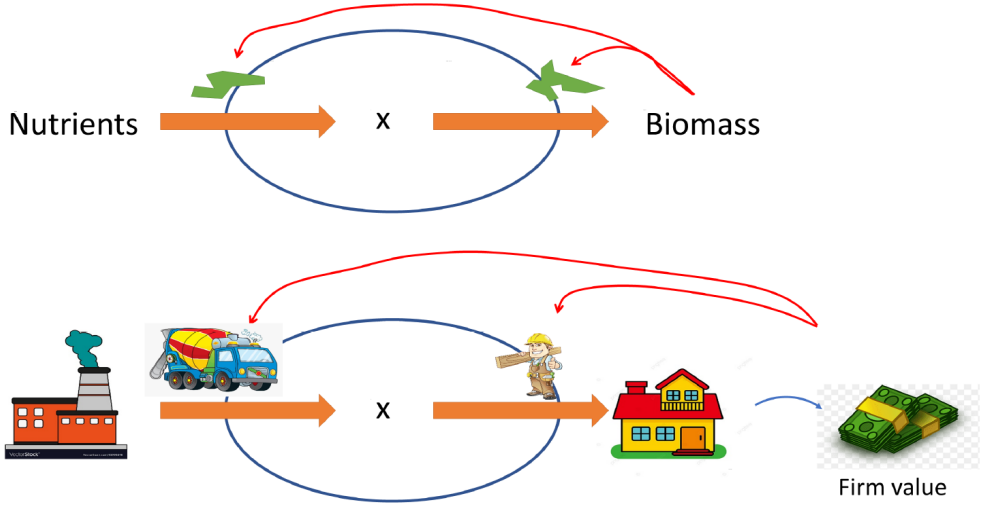
Benefits:

Constraints:

Costs:

Benefits:

Economic principles: Constraints, cost and benefit



Constraints: Diffusion, cell size

Costs: Enzymes, nutrients, osmotic pressure, toxic metabolites

Benefits: Biomass production

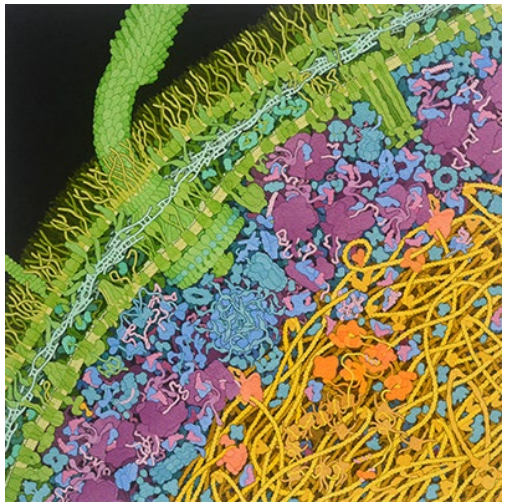
Constraints: Working hours

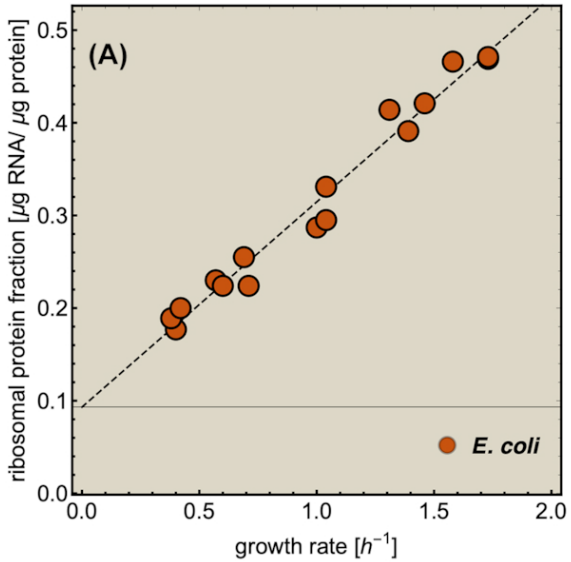
Costs: Personnel, materials, machines

Benefits: Revenue

Economic principles: Constraints

Physical constraints versus observed constraints





What do we want to understand?

Why do cells behave as they do?

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- Why do they respond to the environment as they do?
- …

<u>The summer school</u>

Part 1: The ingredients

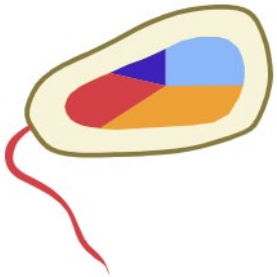
Part 2: ‘Economical explanations’

Part 3: Extensions

The summer school Part 1: The ingredients

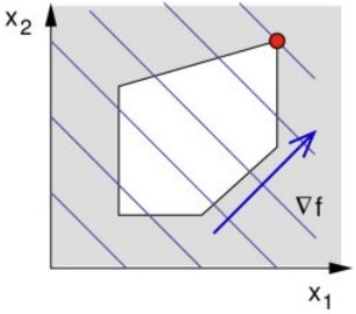
Monday 11am:
An inventory of cell components

- What is there in a cell?
- What do we want to explain?



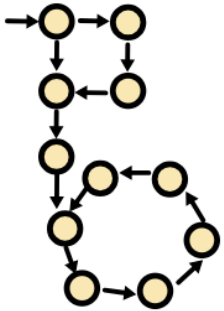
Monday 1pm:
Optimality in biology

- Different optimality methods
- Mathematical descriptions



Monday 2pm:
Cell metabolism

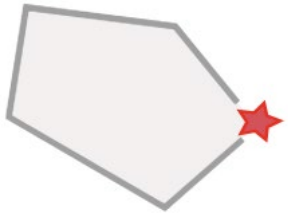
- The metabolic pathways
- How are they regulated



The summer school Part 2: ‘Economical’ explanations

Monday 3:30pm:
Optimization of metabolic fluxes

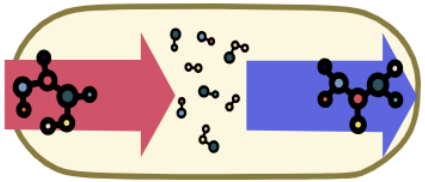
- The flux space
- Which fluxes maximize growth?



Tuesday 10am:
Principles of cell growth

Tuesday 11am:
Growth balance analysis

- Optimize the production of new cells

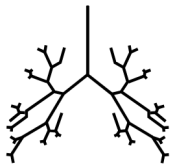


Tuesday 2pm:
Scaling laws in cell evolution

- Scaling in cell size
- Comparing pro- and eukaryotes

Wednesday 10am:
Economy of organ form and function

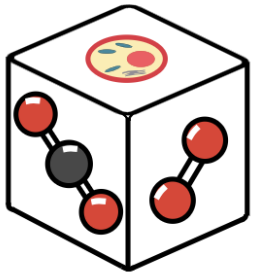
- Constraints on organ morphology
- Scalin



The summer school Part 3: Extensions

Tuesday 3:30pm:
Cells in the face of uncertainty

- Optimize for unknown environment

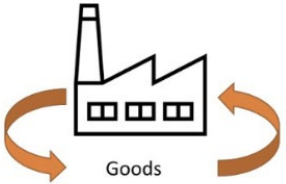


Wednesday 2pm:
The origin of life

- How metabolism started
- Autocatalytic cycles

Wednesday 3:30pm:
The return on investment in cells

- Unifying framework
- Linking back to economics

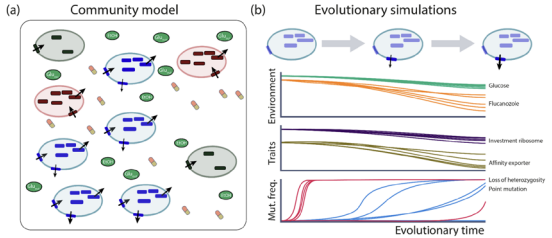


Schedule

Monday	Tuesday	Wednesday	Thursday
(10 am) **The economy of the cell** Meike Wortel	(10 am) **Principles of cell growth** Hollie J. Hindley	(10 am) **Economy of organ form and function** Frédérique Noël	**Atelier SEnS** All day (9am - 5pm)
(11 am) **An inventory of cell components** Diana Széliová / Pranas Grigaitis	(11 am) **Growth balance analysis** Hugo Dourado	(11 am) **Diversity of metabolic flux distributions** Roberto Mulet	
(noon) **Lunch break** and get-together	(noon) **Lunch break** and group photo	(noon) **Lunch break**	
(1 pm) **Optimality in biology** Markus Köbis	(1 pm) **Free discussion/group work**	(1 pm) **Book - plans for the future** Plenary discussion	
(2 pm) **Cell metabolism** Orkun Soyer	(2 pm) **Scaling laws in cell evolution** Sergio Munoz-Gomez	(2 pm) **The origin of life** Sanjay Jain	
Coffee break (3 pm)	Coffee break (3 pm)	Coffee break (3 pm)	
(3:30 pm) **Optimization of metabolic fluxes** Steffen Waldherr	(3:30 pm) **Cells in the face of uncertainty** David Lacoste / Olivier Rivoire	(3:30 pm) **The return on investment in cells** H.-S. Song / D. Ramkrishna	
Guided tour of the LPI (4:30 pm) Virginie Chomier	(4:30 pm) **Night Science** Martin Lercher	(4:30 pm) **Course feedback**	
		Get-together (7:30 pm)	

Postdoc Position (3yr)

Multiscale modelling of antibiotic resistance evolution in *Candida*



International Human Frontier Science Program Organization

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