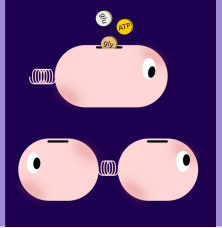


Economic Principles in Cell Biology

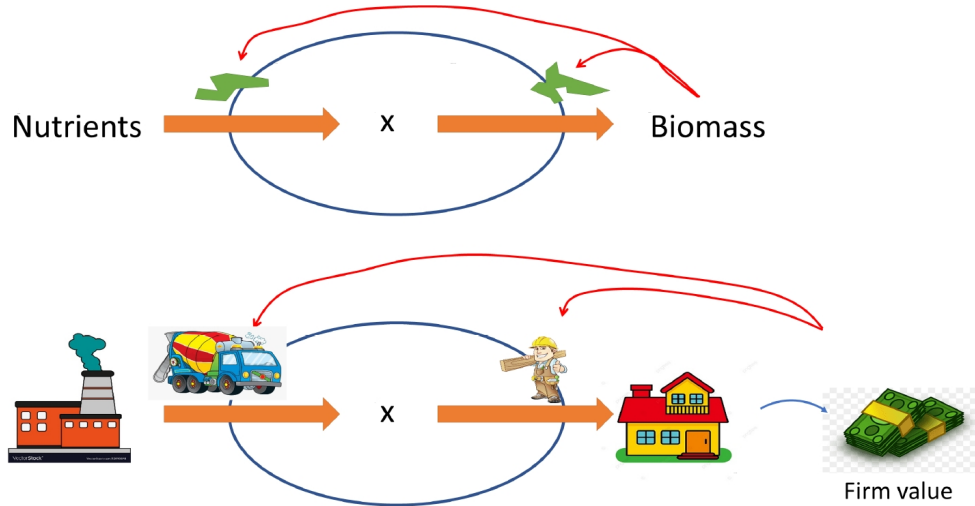
Paris, July 10-14, 2023



Exploring the economy of the cell

Meike Wortel

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

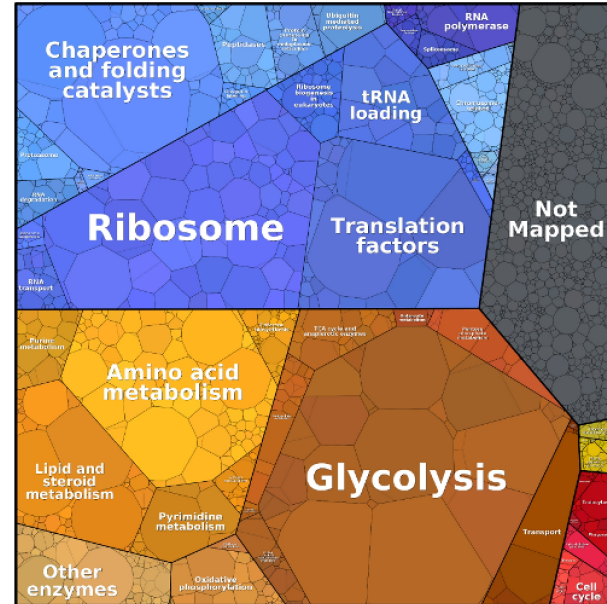


Converting nutrients into biomass with the ‘workers’ that are available.



Two answers to the ‘why question’

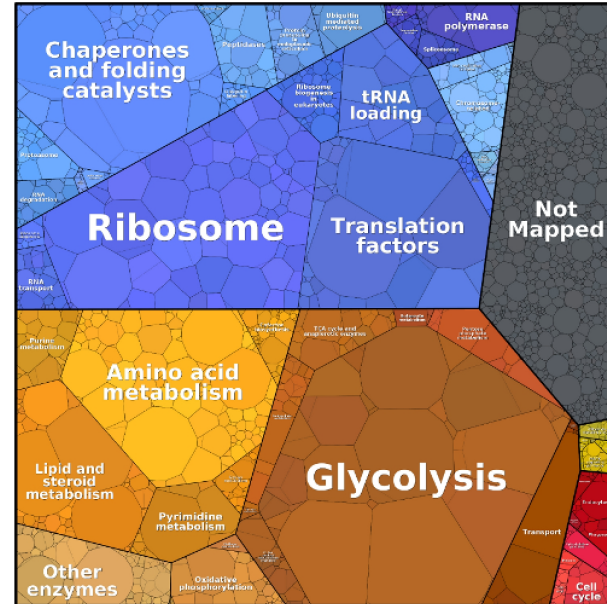
“Why do cells use a large fraction of the proteome for glycolysis?”



Two answers to the ‘why question’

“Why do 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

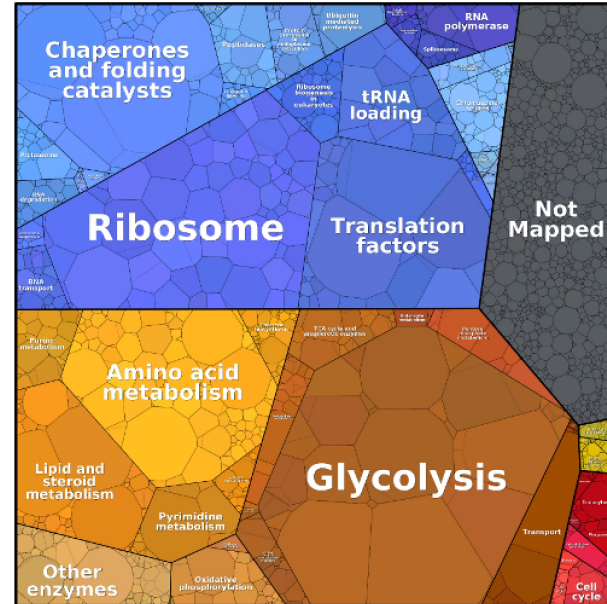


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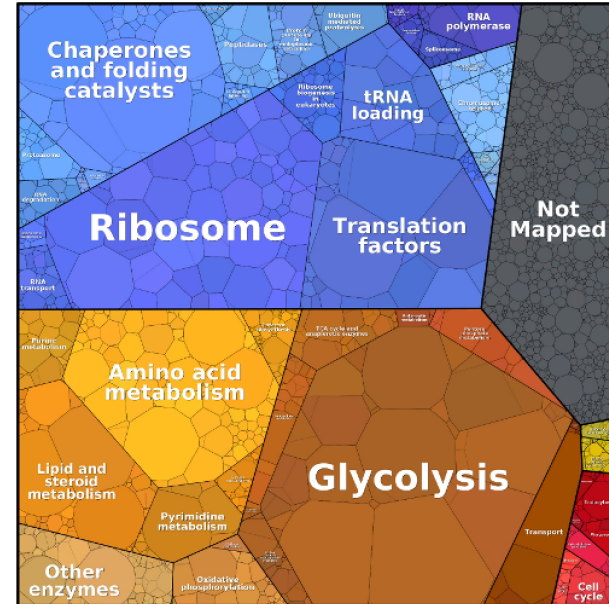
“Proximate explanation”



Two answers to the ‘why question’

“Why do 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 replaced by competitors



Two answers to the ‘why question’

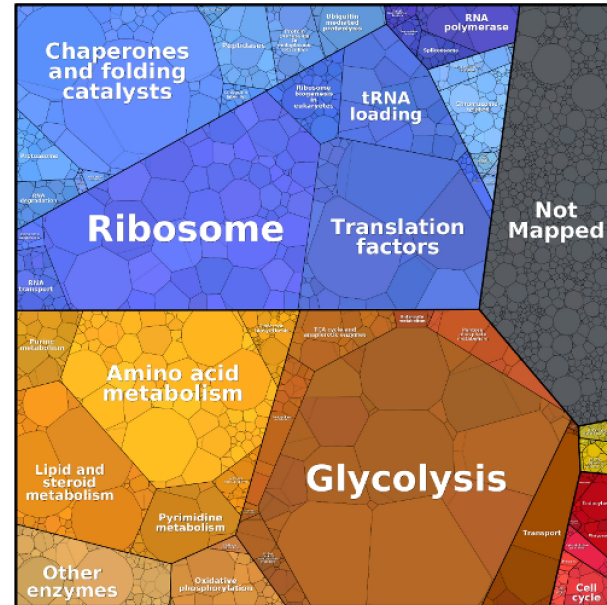
“Why do cells use a large fraction of the proteome for glycolysis?”

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 replaced by competitors

“Evolutionary explanation”

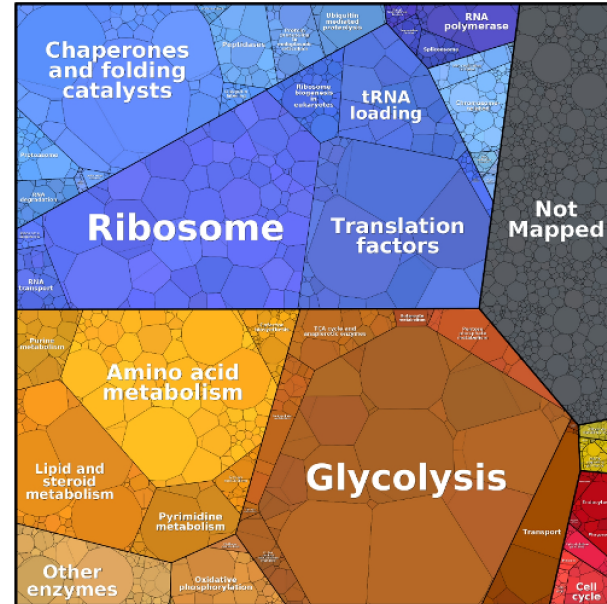


Focus on evolutionary explanation

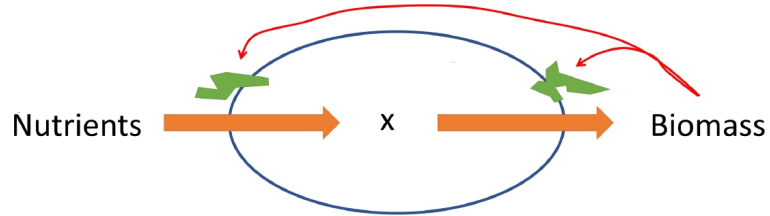
Assuming that:

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

Uncover the “economic principles” that that resulting phenotypes follow using mathematical techniques.

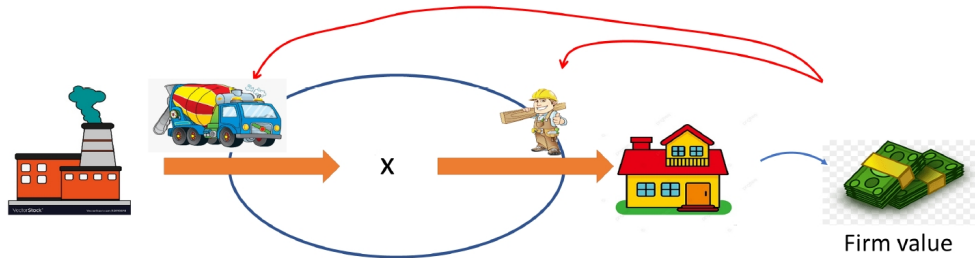


Economic principles: Cost and benefit



Costs: Enzymes, nutrients, osmotic pressure, toxic metabolites

Benefits: Biomass production



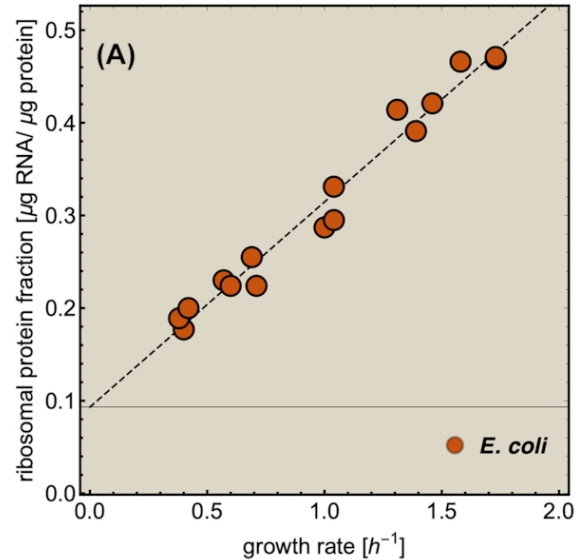
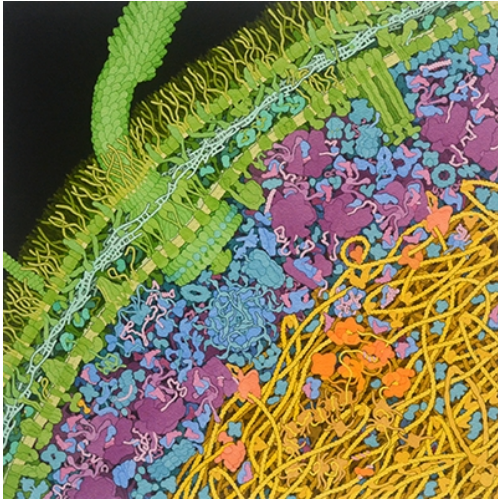
Costs: Personnel, materials, machines

Benefits: Revenue

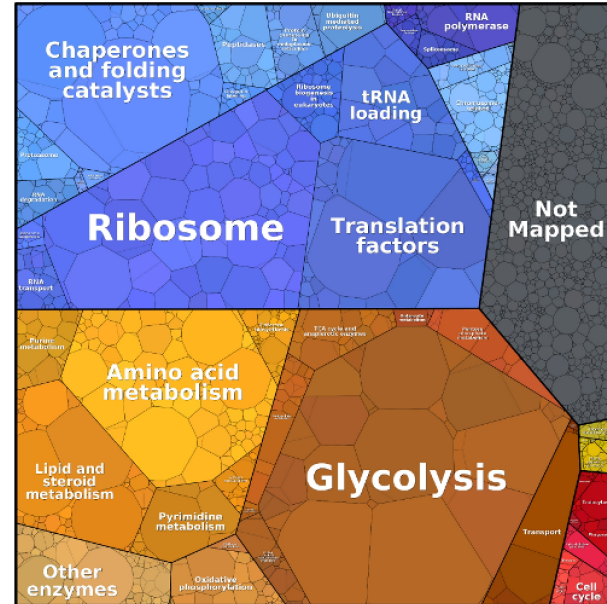
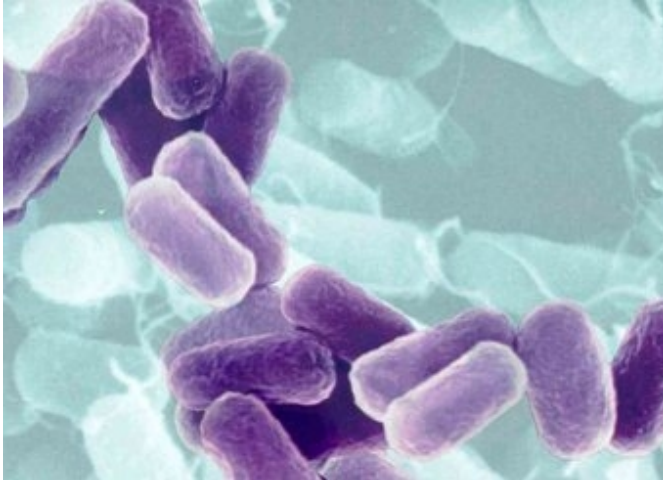


Economic principles: Constraints

Physical constraints versus observed constraints



“Why are cells with certain properties selected for?”



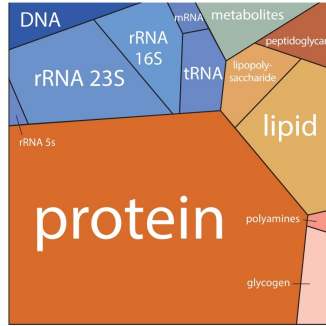
How are protein (and other) resources allocated?

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

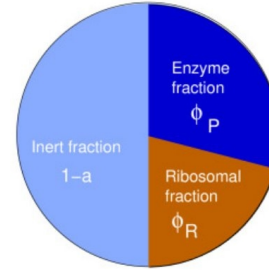


Outline of the summer school - Monday

What makes up a cell?



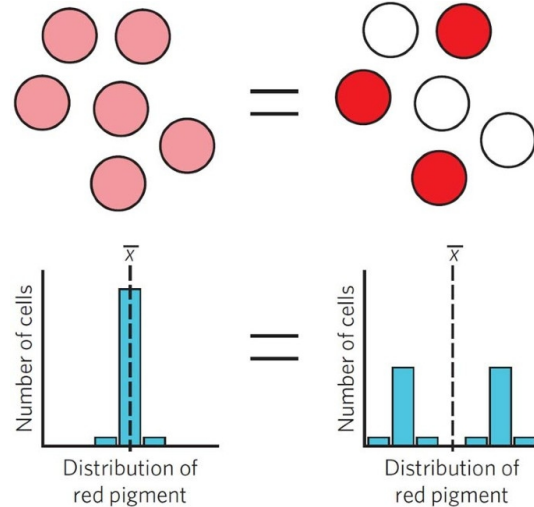
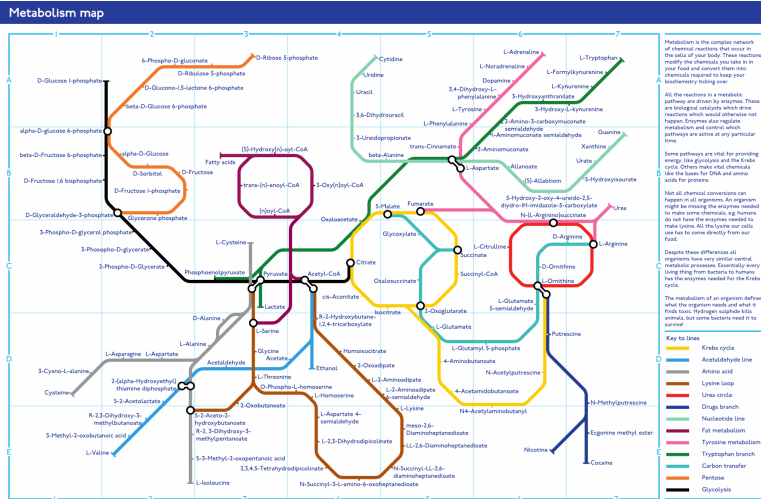
- What are the properties?
- What are the constraints?



What global processes do cells invest in under different conditions?



Outline of the summer school - Tuesday



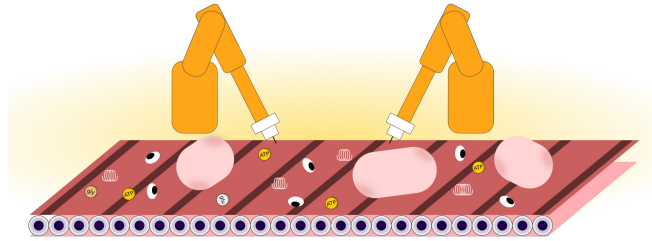
How are resources allocated in metabolic pathways?

When is it a good strategy to have different strategies in a population (“Bet hedging”)

Figure: Lindstrom & Konopka, 2010

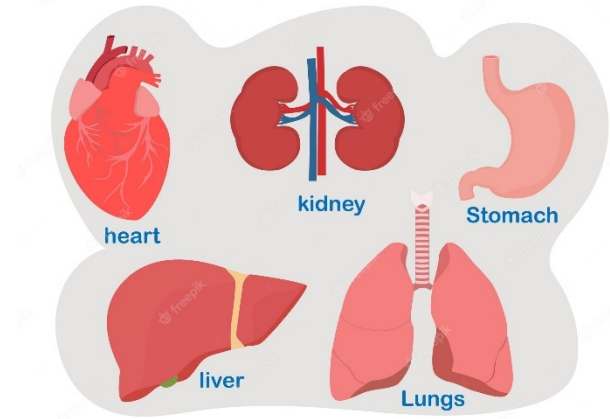


Outline of the summer school - Wednesday



Optimal scheduling:
How should cells allocate resources in time?

And if the environment changes or cannot be predicted?



Extend the economic principles to larger systems.

