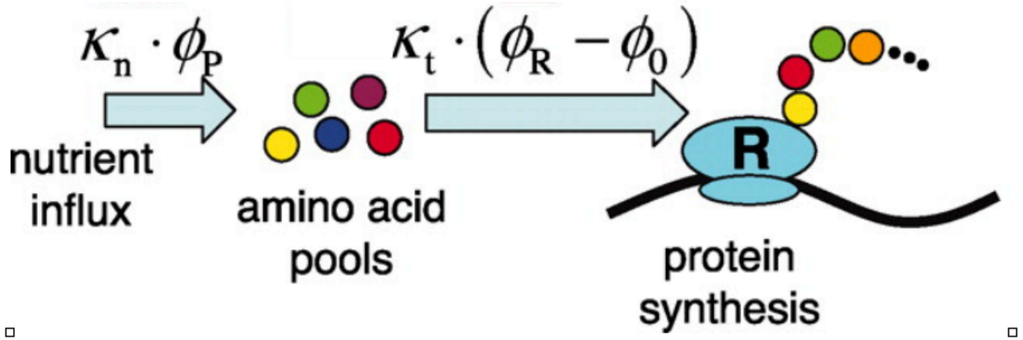
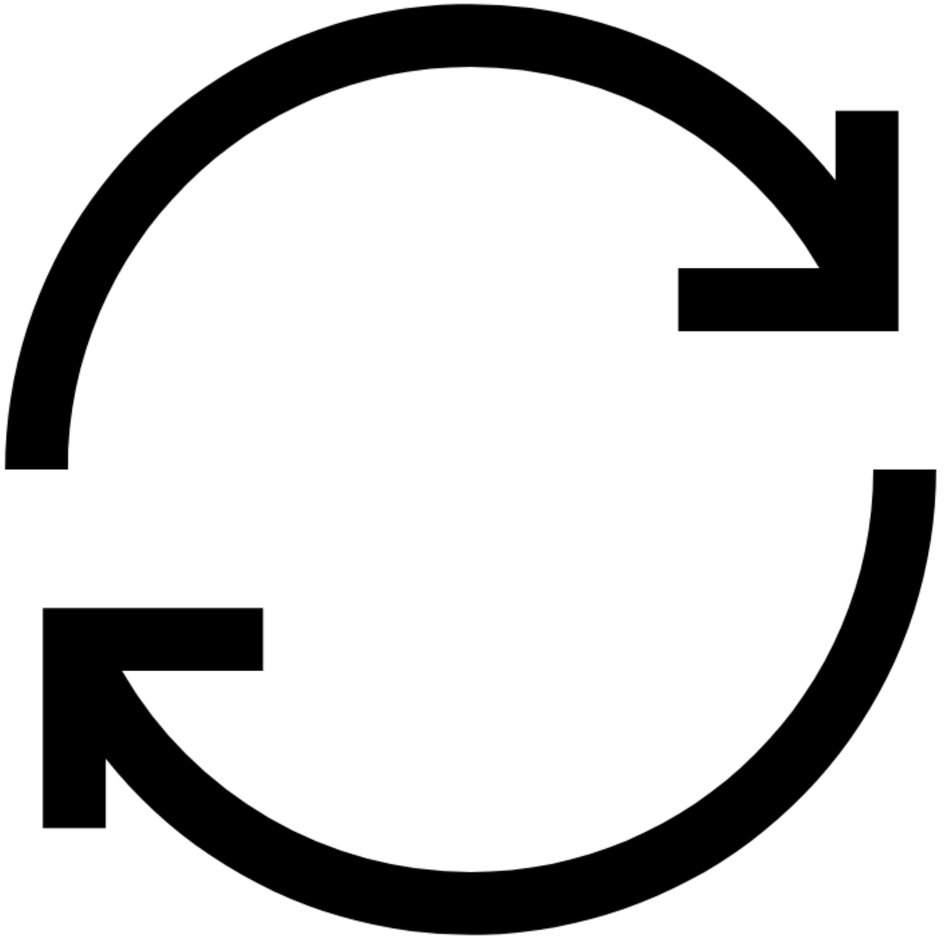
Quantitative Microbial Physiology

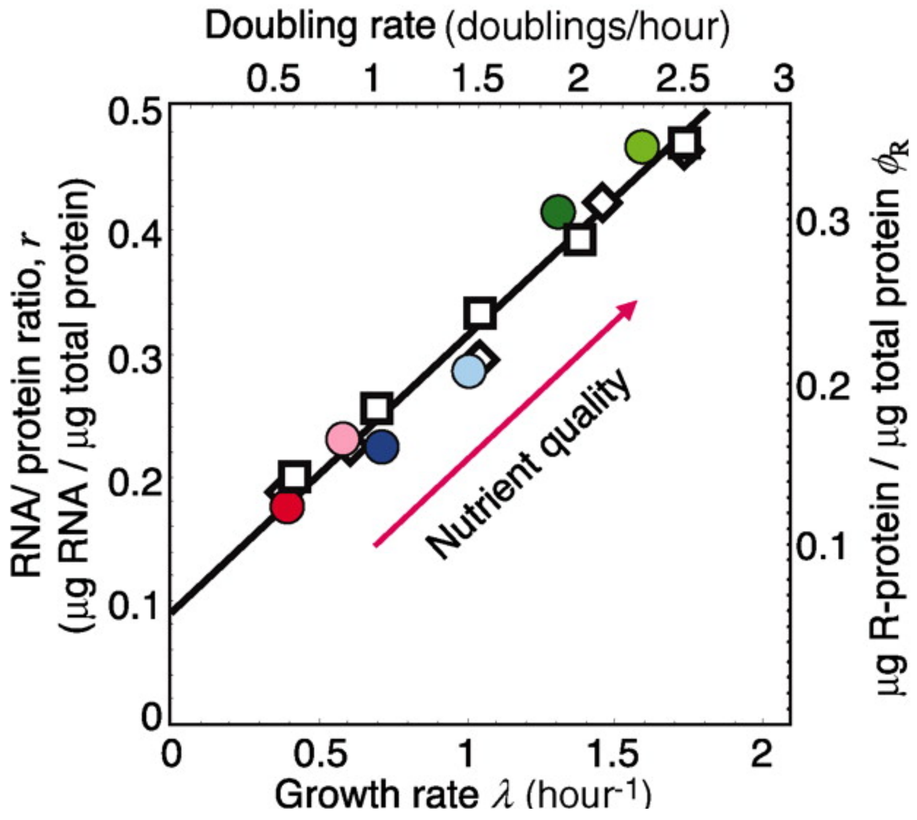
Jacopo Grilli

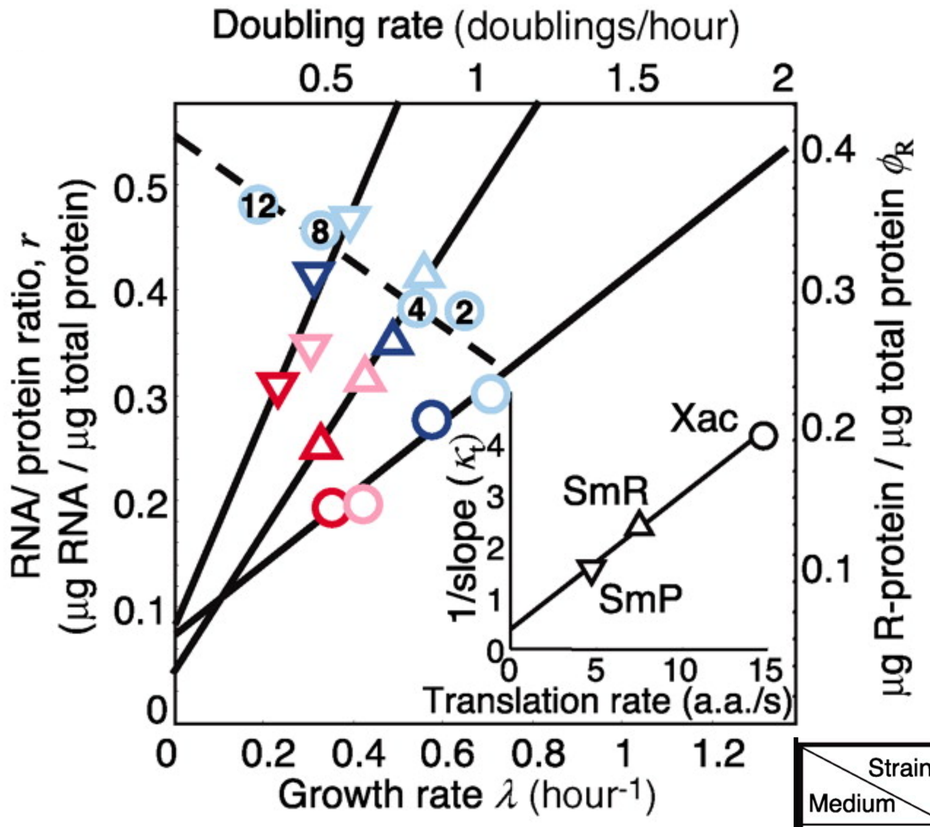
Lecture 4, Feb 20, 2025


$\kappa_n \cdot \phi_P$
$\kappa_t \cdot (\phi_R - \phi_0)$
nutrient influx
amino acid pools
R
protein synthesis



First growth law again

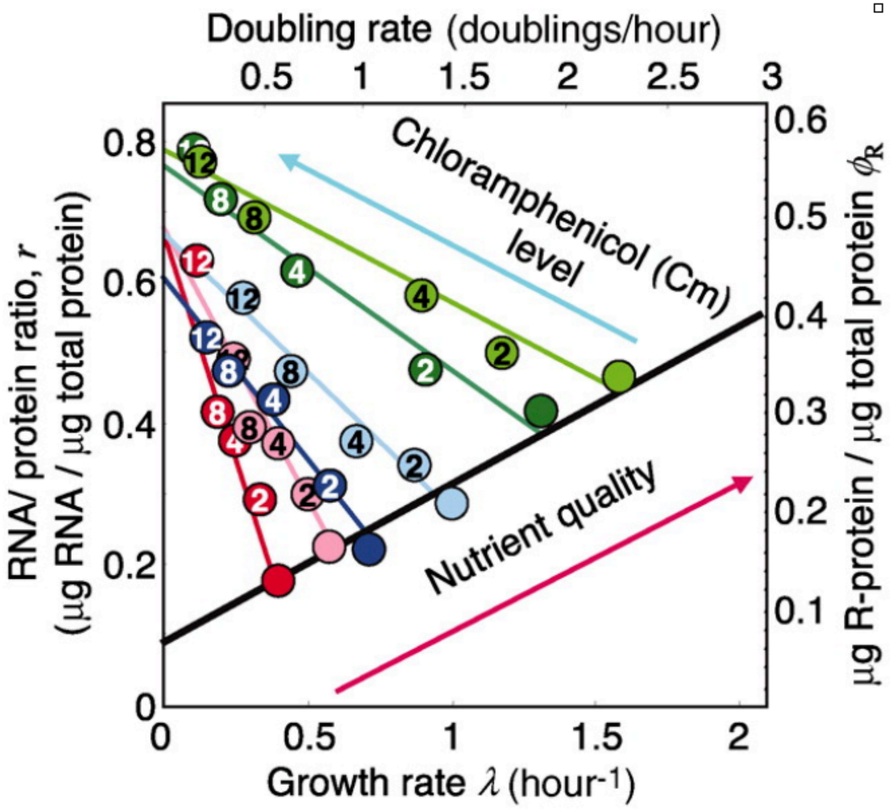


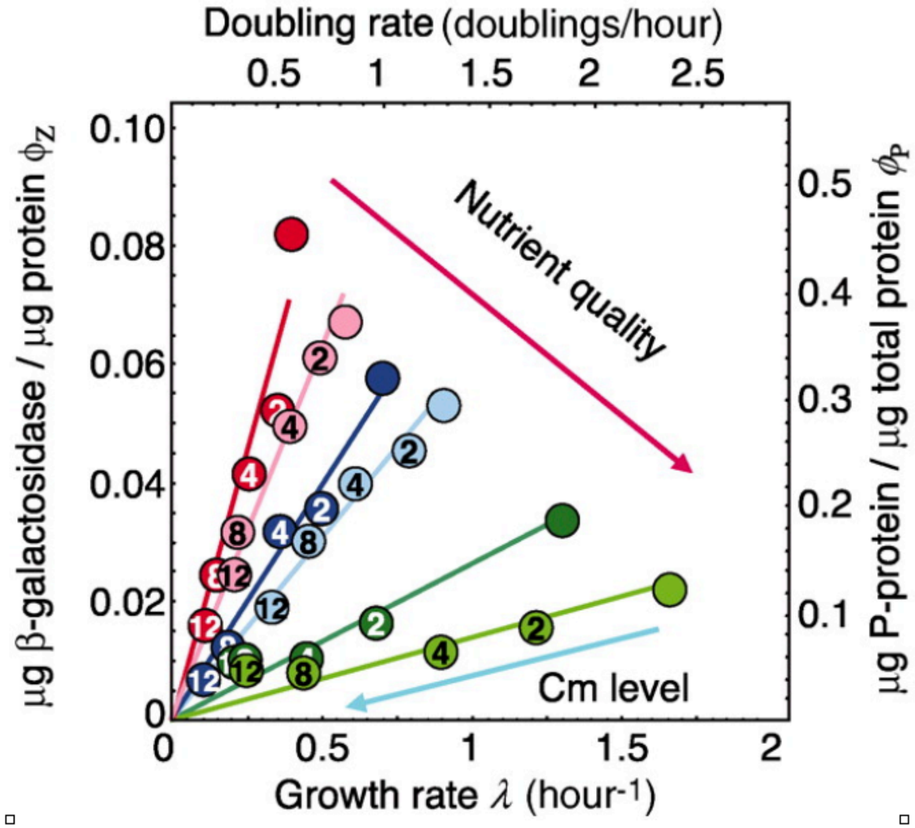


Strain / Medium	EQ2	Xac	SmR	SmP	Xac in cAA+glc Cm conc. (μM)	
M63+glyc	●	○	△	▽	2	2
M63+gluc	●	○	△	▽	4	4
cAA+glyc	●	○	△	▽	8	8
cAA+gluc	●	○	△	▽	12	12
RDM+glyc	●	Historical data: □ Strain B/r; Ref. (*10*) ◇ Strain 15τ-bar; Ref. (*12*)				
RDM+gluc	●					

Scott et. al (2010)

R- and P- sector under both limitations

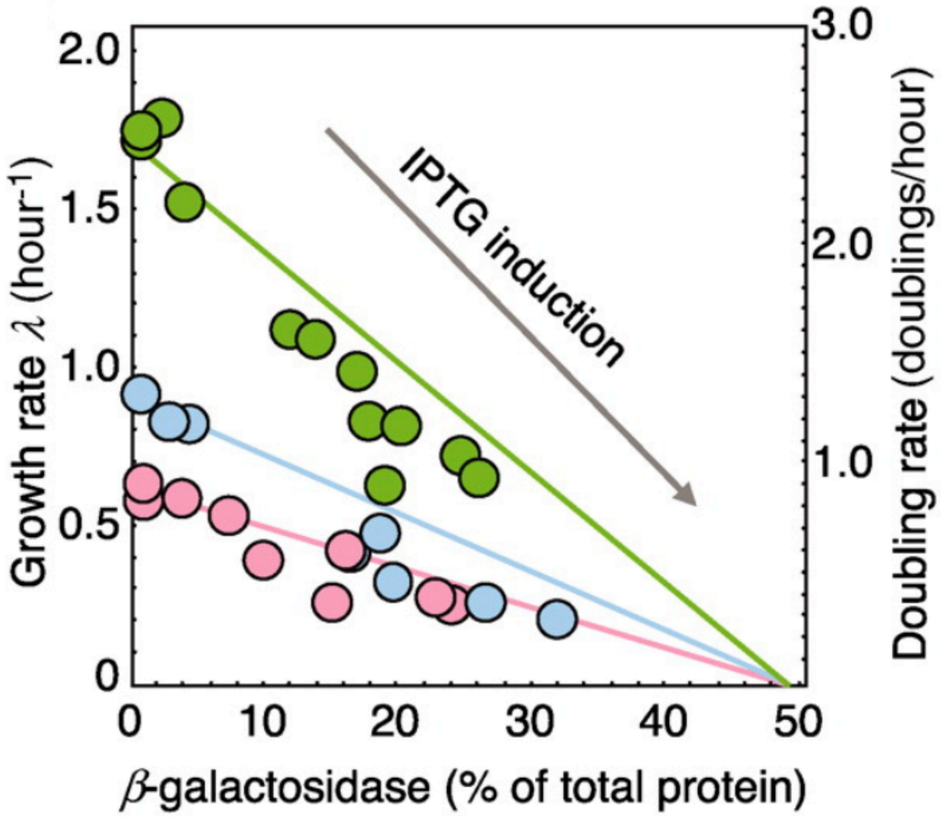




Medium \ Strain	EQ2/EQ3 Chloramphenicol conc. (μM)				
	0	2	4	8	12
M63+glyc	●	2	4	8	12
M63+gluc	●	2	4	8	12
cAA+glyc	●	2	4	8	12
cAA+gluc	●	2	4	8	12
RDM+glyc	●	2	4	8	12
RDM+gluc	●	2	4	8	12

Scott et. al (2010)

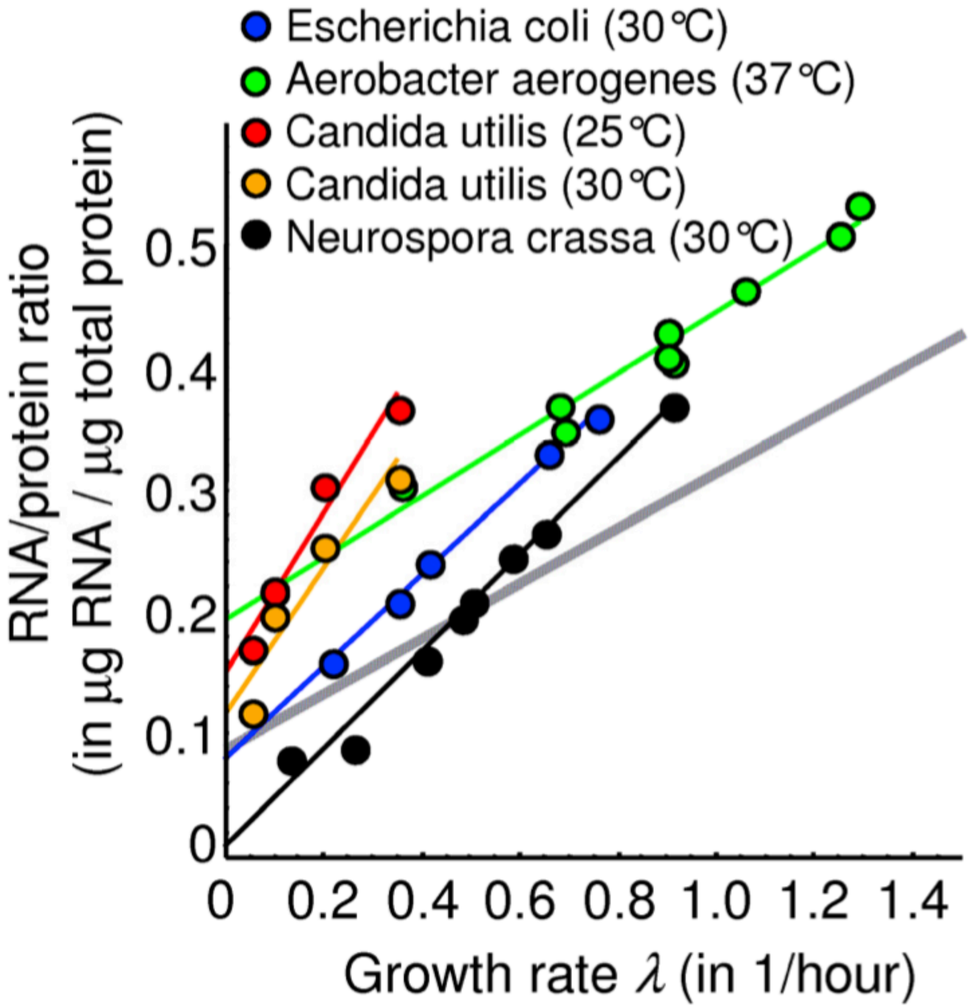
Over-expressing proteins decreases the growth rate as predicted

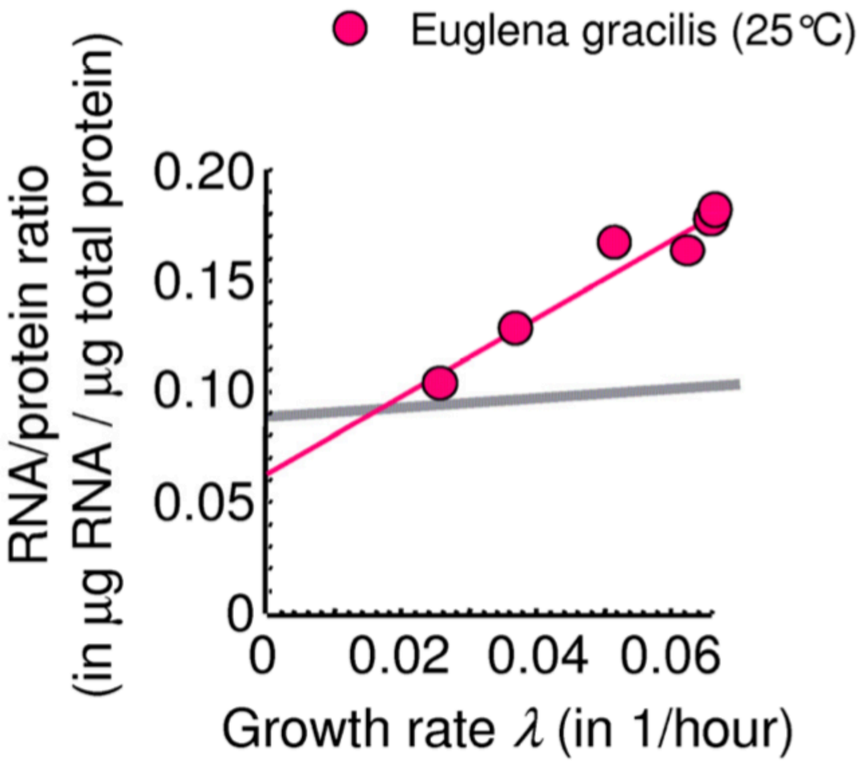


M63+glyc	
M63+gluc	
cAA+glyc	
cAA+gluc	
RDM+glyc	
RDM+gluc	

Scott et. al (2010)

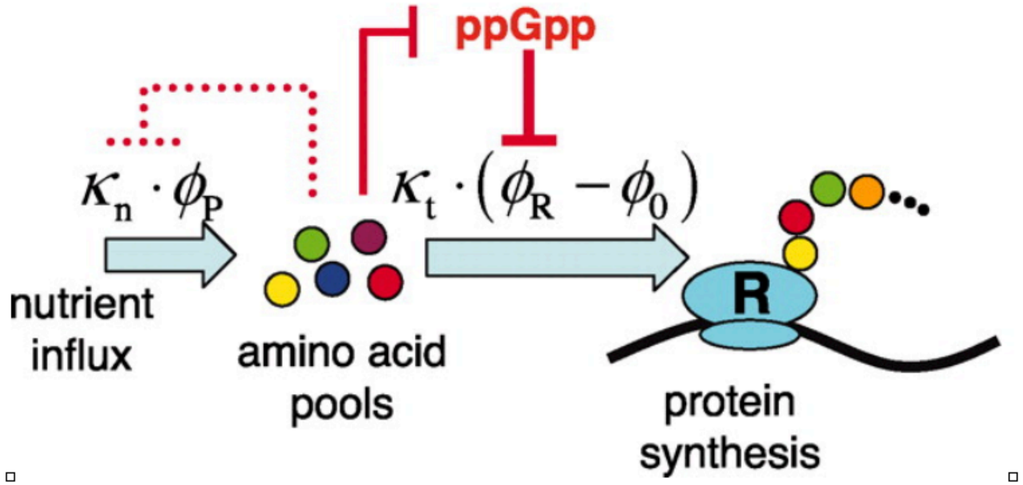
The same patterns apply beyond E. coli





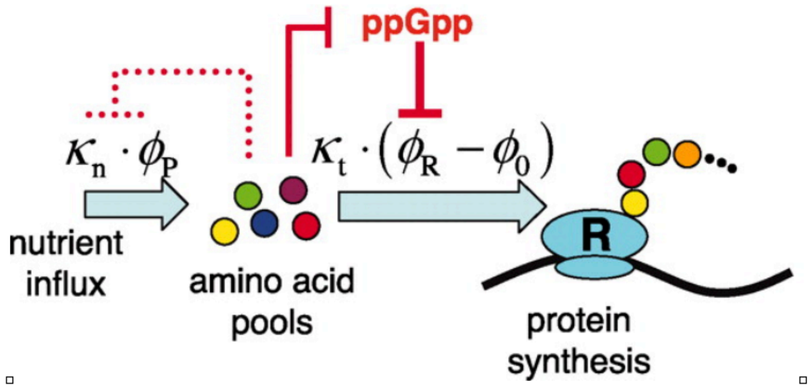
Scott et. al (2010)

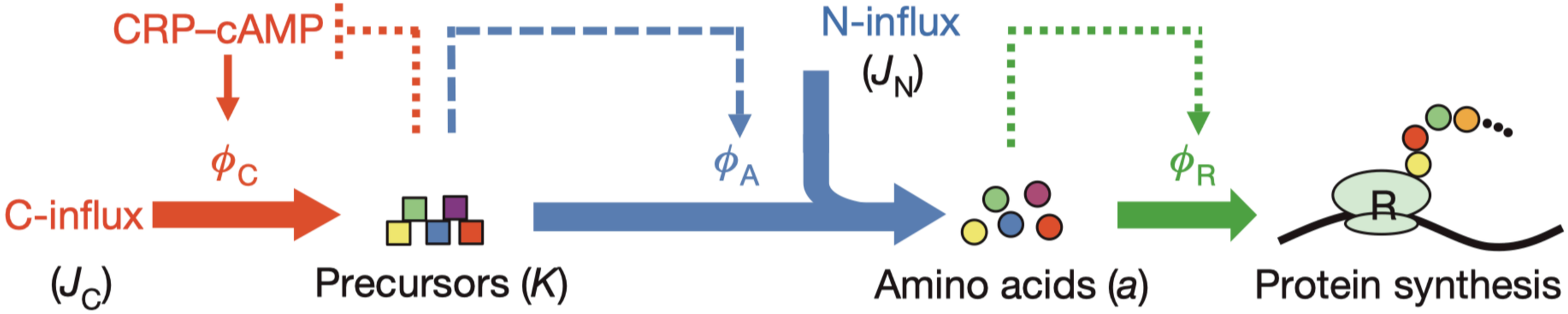
This is simple because is a steady-state



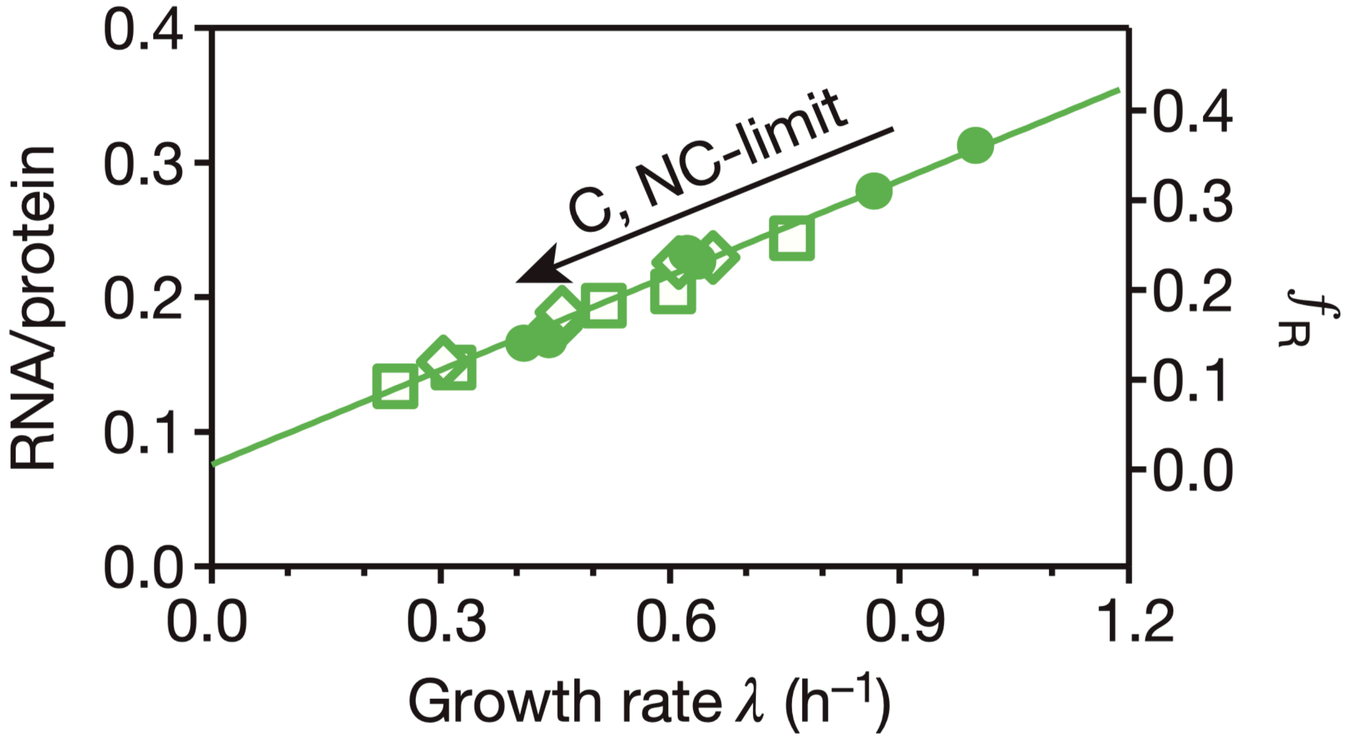
If you like out of steady state see Droghetti et al., https://www.biorxiv.org/content/10.1101/2023.10.25.563923v2

Extending the framework to catabolic/anabolic processes





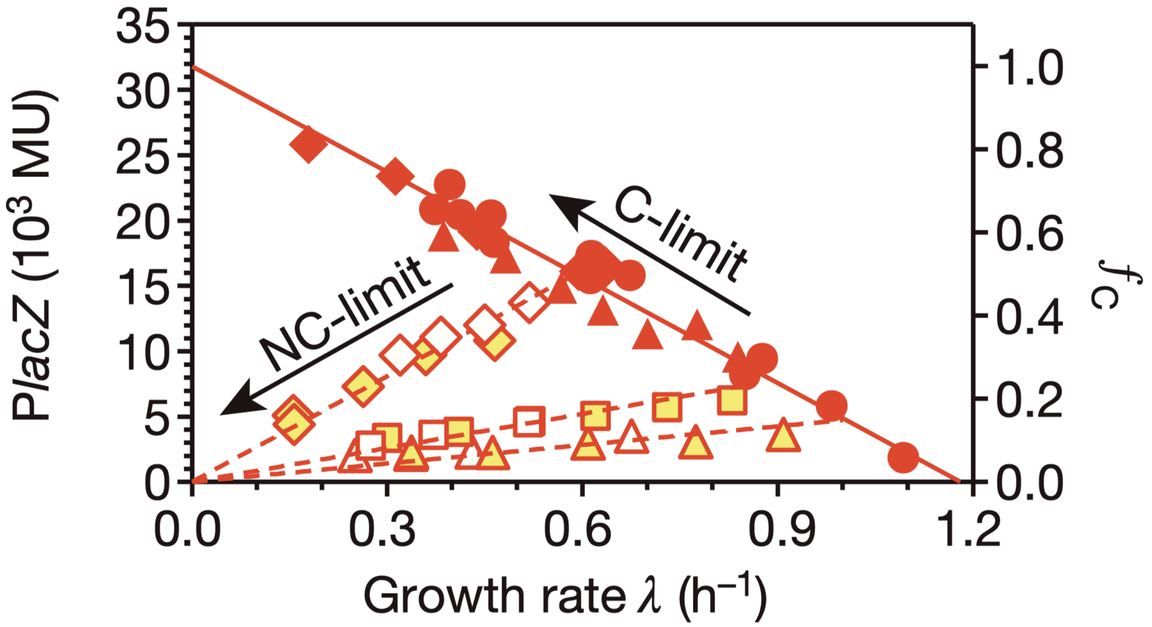
First growth law under C- and A- lim



	Strain	Description	Carbon	LacZ	cAMP	RNA/protein
C-limit	NCM3722	WT	Various	Supplementary Table 1 (5)	Supplementary Table 8	Supplementary Table 10 (14)
	NQ381	Titratable LacY	Lactose	Supplementary Table 2 (5)	Supplementary Table 8	
	NQ399	Titratable GlpFK	Glycerol	Supplementary Table 3 (5)		
	NQ158	P*glnA-lacZ*	Various	Supplementary Table 12 (15)		
			Lactose	Supplementary Table 7 (5)	Supplementary Table 9	
NC(A)-limit	NQ34	Titratable GDH	Glucose	Supplementary Table 7 (5)		Supplementary Table 11 (14)
			Glycerol	Supplementary Table 7 (5)		Supplementary Table 11 (14)
	NCM3722	N-chemostat	Lactose	Supplementary Table 6 (5)		
	NQ354	N-chemostat	Glucose	Supplementary Table 6 (5)		
	NQ354	S-chemostat	Glycerol	Supplementary Table 6 (5)		
	NQ477	P*glnA-lacZ* Titratable GDH	Glycerol	Supplementary Table 13 (15)		

You et. al (2013)

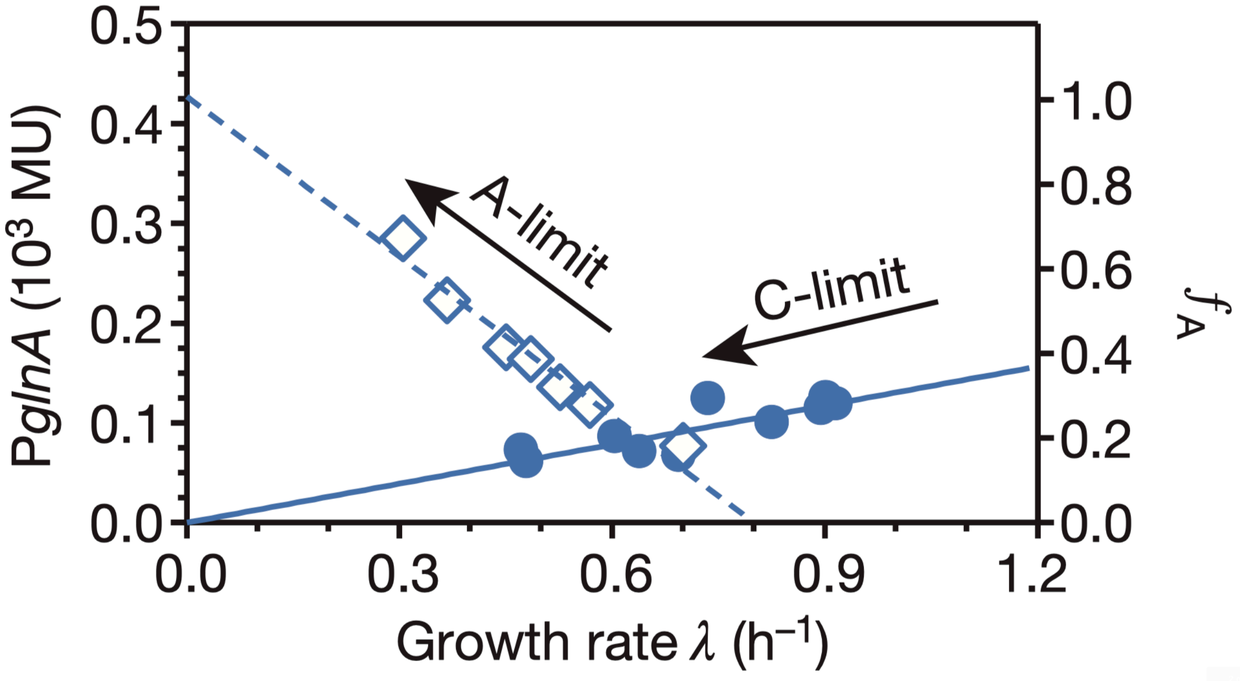
Catabolic and anabolic sec under C- and A- lim



	Strain	Description	Carbon	LacZ	cAMP	RNA/protein
C-limit	NCM3722	WT	Various	Supplementary Table 1 (5) ●	Supplementary Table 8 ●	Supplementary Table 10 (14) ●
	NQ381	Titratable LacY	Lactose	Supplementary Table 2 (5) ▲	Supplementary Table 8 ▲	
	NQ399	Titratable GlpFK	Glycerol	Supplementary Table 3 (5) ◆		
	NQ158	*PglnA-lacZ*	Various	Supplementary Table 12 (15) ●		
NC(A)-limit			Lactose	Supplementary Table 7 (5) △	Supplementary Table 9 △	
	NQ34	Titratable GDH	Glucose	Supplementary Table 7 (5) □		Supplementary Table 11 (14) □
			Glycerol	Supplementary Table 7 (5) ◇		Supplementary Table 11 (14) ◇
	NCM3722	N-chemostat	Lactose	Supplementary Table 6 (5) △		
	NQ354	N-chemostat	Glucose	Supplementary Table 6 (5) □		
	NQ354	S-chemostat	Glycerol	Supplementary Table 6 (5) ◇		
	NQ477	*PglnA-lacZ* Titratable GDH	Glycerol	Supplementary Table 13 (15) ◇		

You et. al (2013)

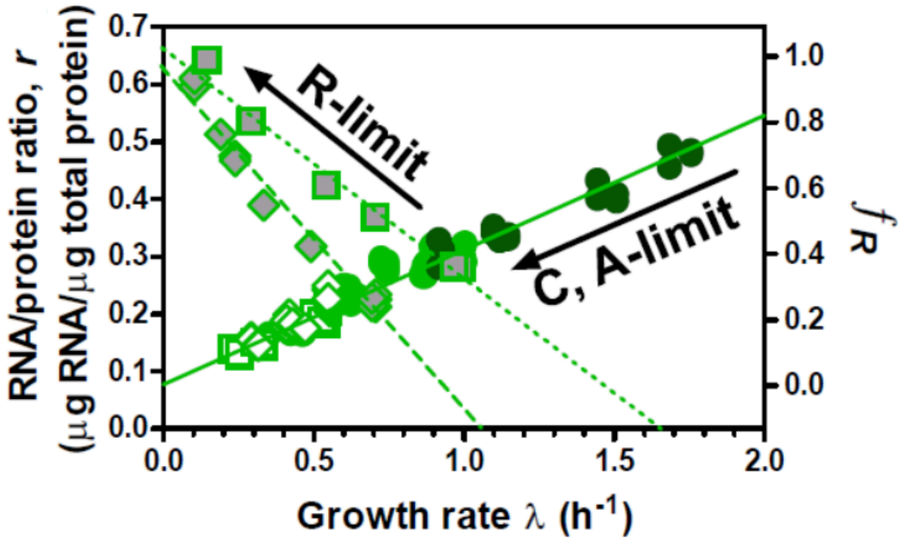
Catabolic and anabolic sec under C- and A- lim

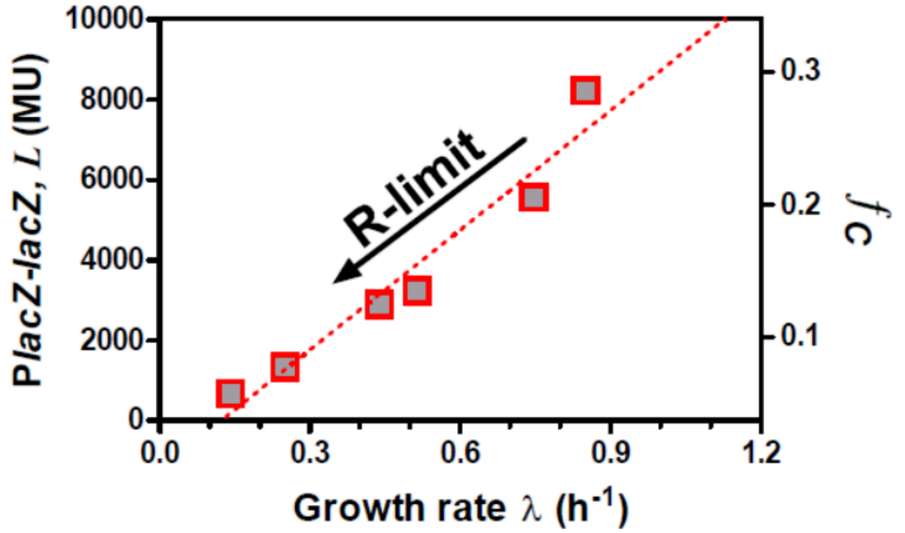


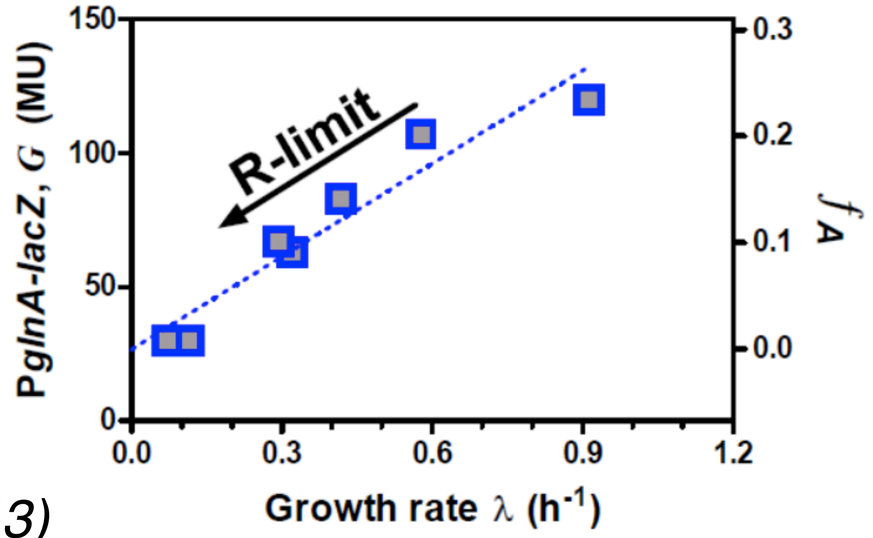
	Strain	Description	Carbon	LacZ	cAMP	RNA/protein
C-limit	NCM3722	WT	Various	Supplementary Table 1 (5) ●	Supplementary Table 8 ●	Supplementary Table 10 (14) ●
	NQ381	Titratable LacY	Lactose	Supplementary Table 2 (5) ▲	Supplementary Table 8 ▲	
	NQ399	Titratable GlpFK	Glycerol	Supplementary Table 3 (5) ◆		
	NQ158	P*glnA-lacZ*	Various	Supplementary Table 12 (15) ●		
NC(A)-limit			Lactose		Supplementary Table 9 △	
	NQ34	Titratable GDH	Glucose			Supplementary Table 11 (14) □
			Glycerol			Supplementary Table 11 (14) ◇
	NCM3722	N-chemostat	Lactose			
	NQ354	N-chemostat	Glucose			
	NQ354	S-chemostat	Glycerol			
	NQ477	P*glnA-lacZ* Titratable GDH	Glycerol	Supplementary Table 13 (15) ◇		

You et. al (2013)

Sectors under R- limitation







	Strain	Description	Carbon	Symbol	
RNA/Protein ratio	NCM3722	WT	rich medium	●	C-limit
			various	●	
	NQ34	ΔGOGAT Titratable GDH	glucose	□	A-limit
			glycerol	◇	
	NCM3722	WT	glucose	■	R-limit
			glycerol	◆	
LacZ	NCM3722	WT; IPTG	glucose	■	
	NQ158	P*glnA -lacZ*	glucose	■	

You et. al (2013)

References

Jun et al., 2018 Rep. Prog. Phys. 81 056601

Brock Biology of Microorganisms

Scott et al., Science 2010

You et al., Nature 2013