Quantitative Microbial Physiology

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Lecture 3, Feb 19, 2025

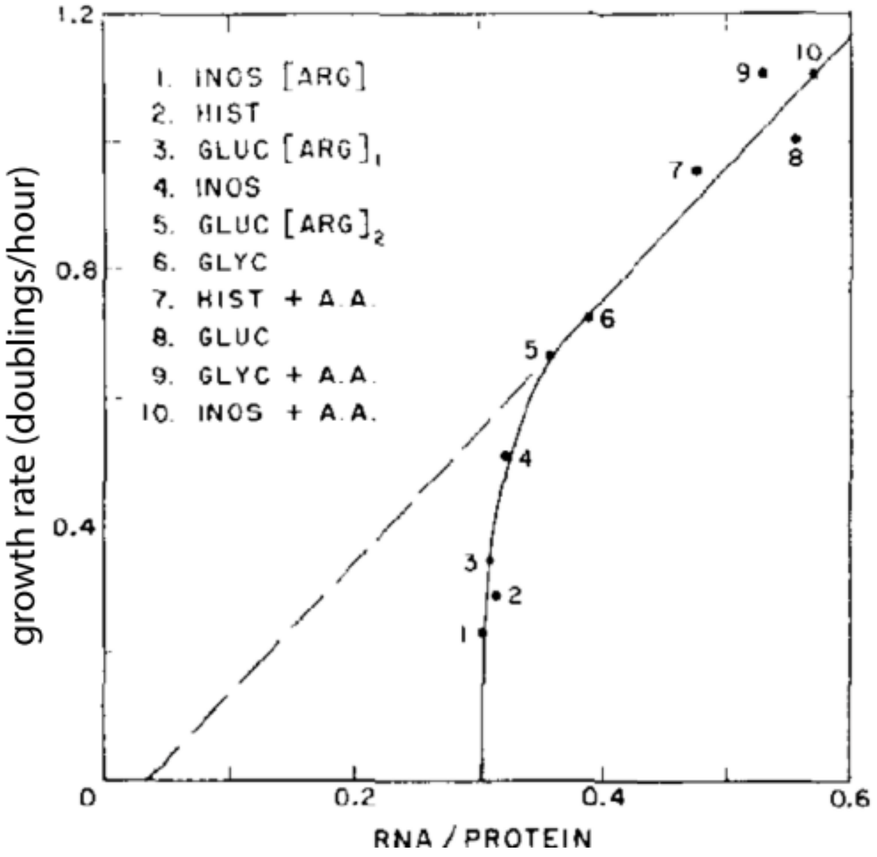
Mostly proteins, mostly ribosomes
How does this depends on growth condition?

TABLE 1. Composition of an average *E. coli* B/r cell[a]

Component(s)	% Total dry wt[b]	Amt (g, 10^{15})/cell[c]	Mol wt	Molecules/cell	No. of different kinds of molecules[d]
Protein	55.0	156	4.0×10^4-	2,350,000	1,850
RNA	20.5	58			
23 S rRNA		31.0	1.0×10^6	18,700	1
16 S rRNA		15.5	5.0×10^5	18,700	1
5 S rRNA		1.2	3.9×10^4	18,700	1
Transfer		8.2	2.5×10^4	198,000	60
Messenger		2.3	1.0×10^6	1,380	600
DNA	3.1	8.8	2.5×10^9	2.1	1
Lipid	9.1	25.9	705	22,000,000	
Lipopolysaccharide	3.4	9.7	4,070	1,430,000	1
Peptidoglycan	2.5	7.1	(904)*n*	1	1
Glycogen	2.5	7.1	$1.0 \times !0^6$	4,300	1
Polyamines	0.4	1.1			
Putrescine		0.83	88	5,600,000	1
Spermidine		0.27	145	1,100,000	1
Metabolites, cofactors, ions	3.5	9.9			800+

[a] Calculated for an average cell in a population of *E. coli* B/r in balanced growth at 37°C in aerobic glucose minimal medium with a mass doubling time of 40 min. The cell is defined by dividing the total biomass, or the amount of any of its measured

First growth law: ribosome fraction increases linearly with growth rate



Neidhardt and Magasanik (1960)

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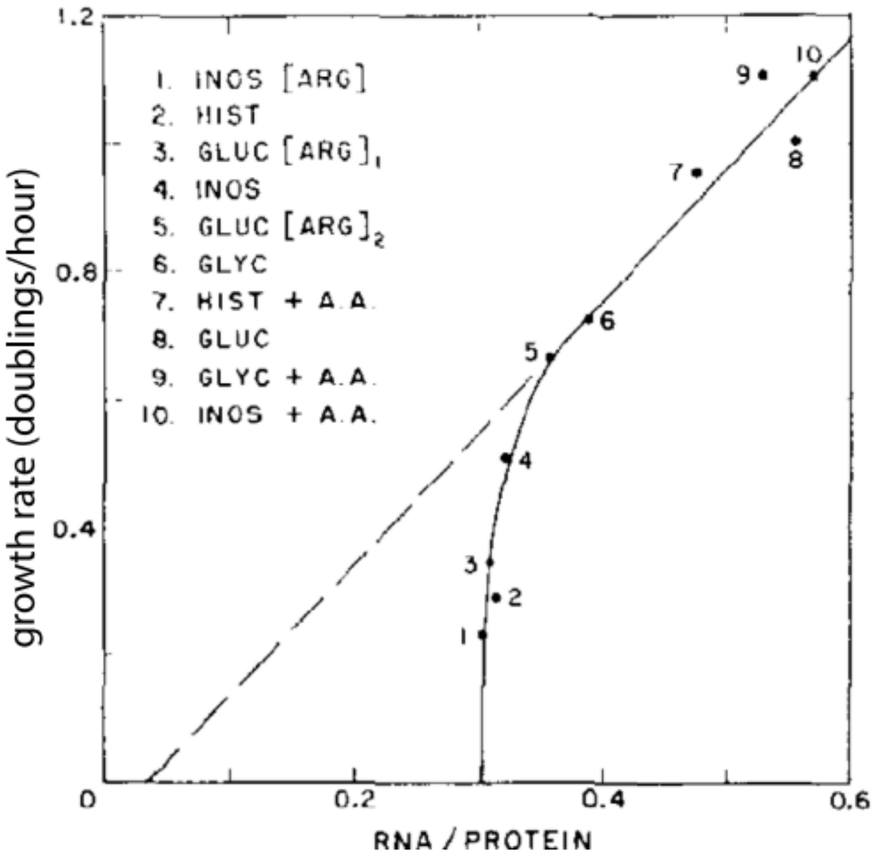
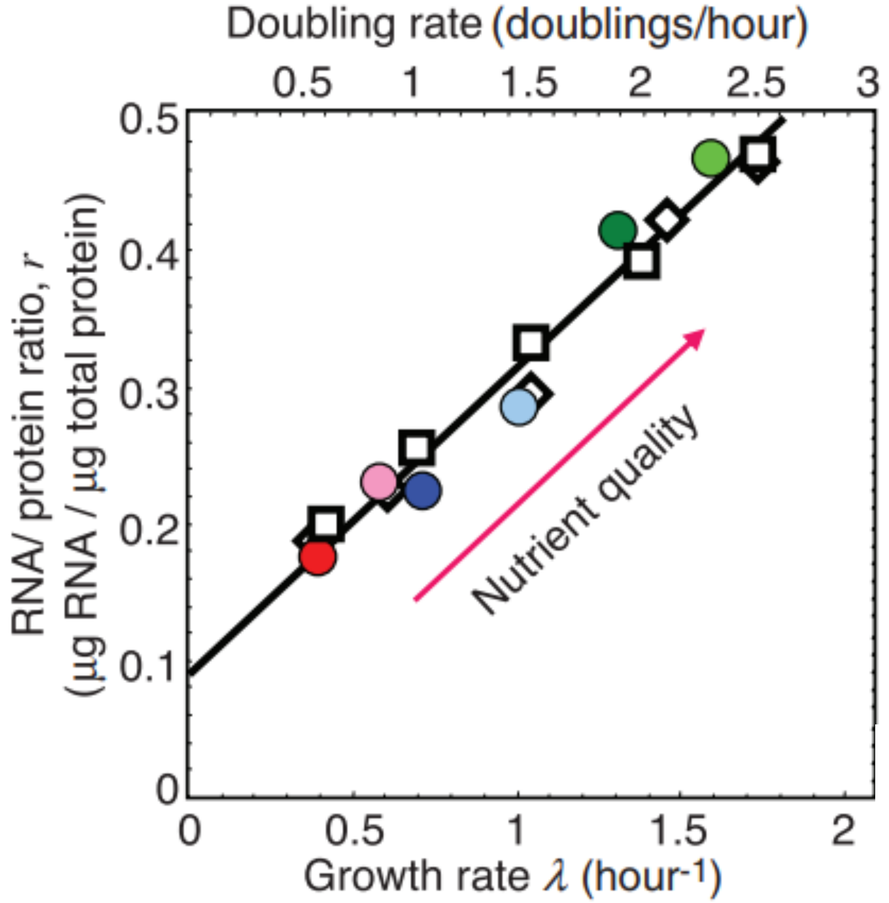


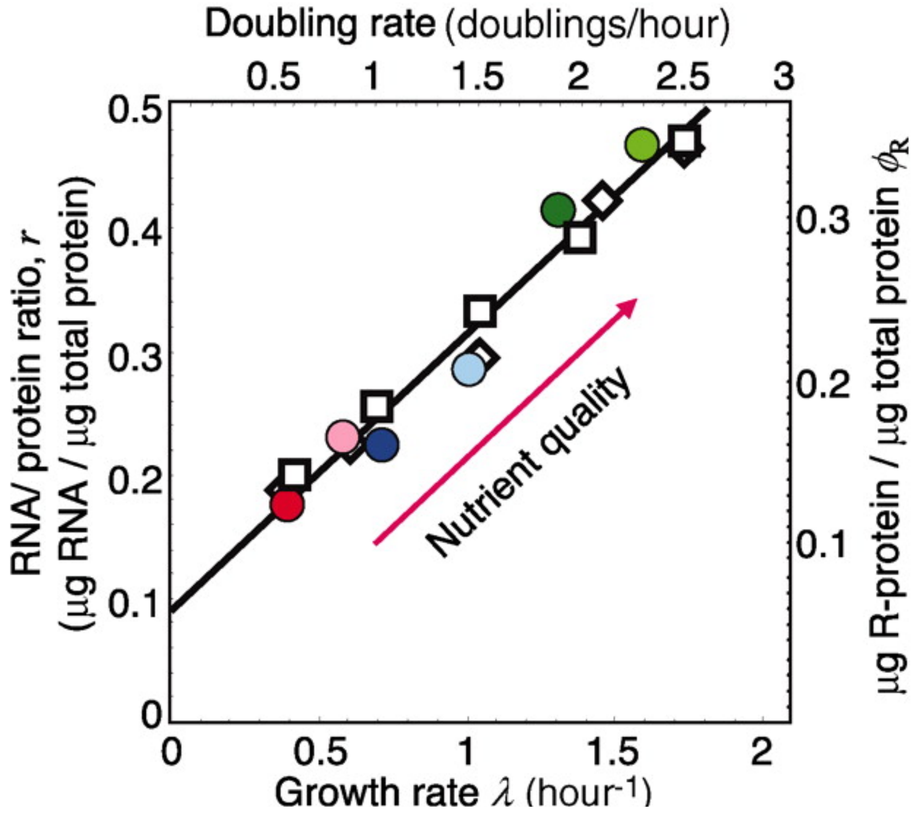
Neidhardt and Magasanik (1960)

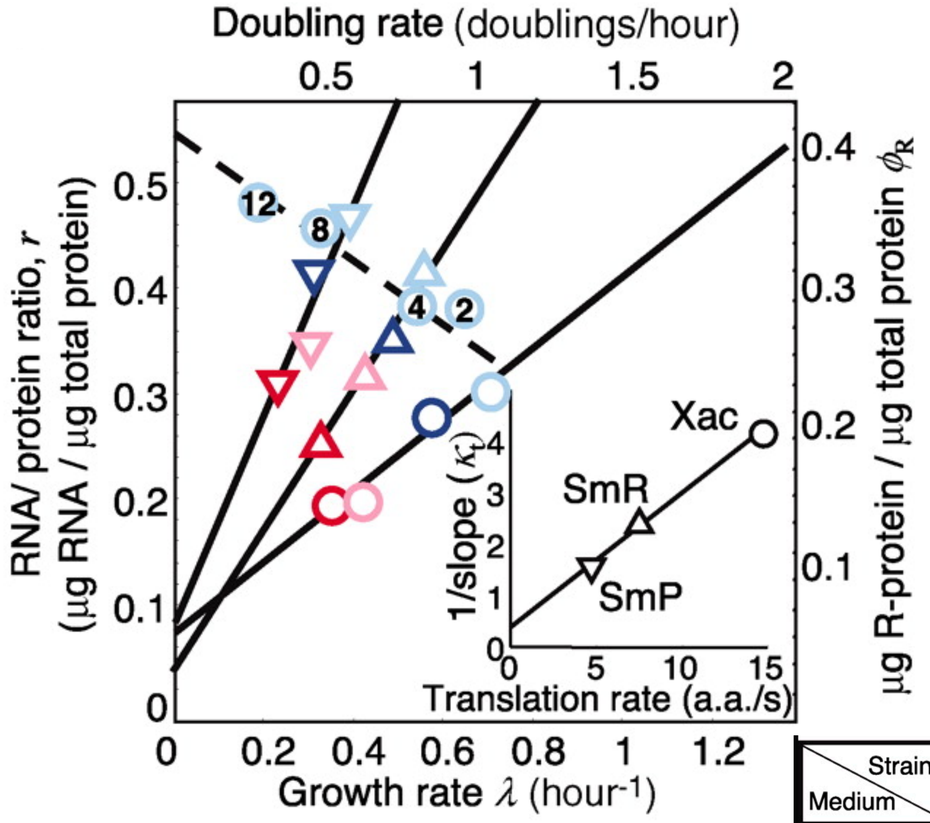


Scott et. al (2010)

Medium \ Strain	EQ2
M63+glyc	●
M63+gluc	●
cAA+glyc	●
cAA+gluc	●
RDM+glyc	●
RDM+gluc	●

Mutants with slower ribosomes have a larger slope as predicted

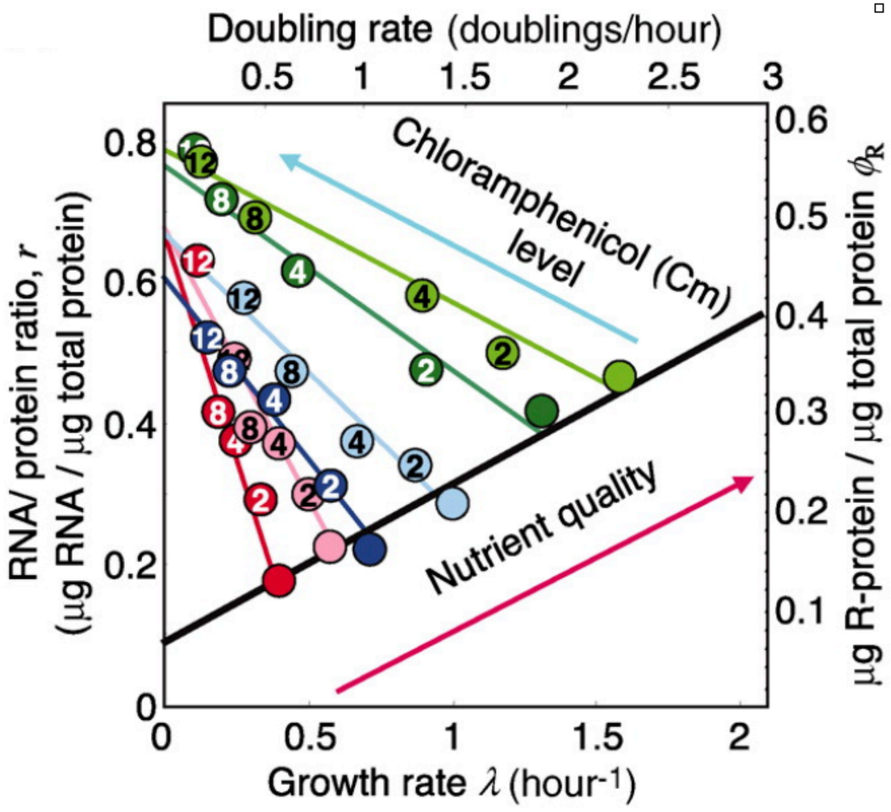




Strain / Medium	EQ2	Xac	SmR	SmP	Xac in cAA+glc Cm conc. (μM)	
M63+glyc	●	○	△	▽	2	2
M63+gluc	●	○	△	▽	4	4
cAA+glyc	●	○	△	▽	8	8
cAA+gluc	●	○	△	▽	12	12
RDM+glyc	●	Historical data:	□ Strain B/r; Ref. (*10*)			
RDM+gluc	●		◇ Strain 15τ-bar; Ref. (*12*)			

Scott et. al (2010)

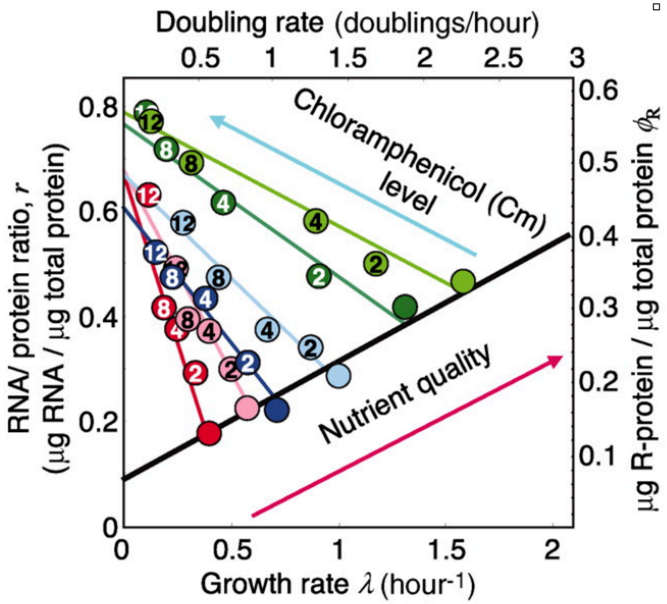
Adding antibiotics change the relatioship between ribosomes and growth rate

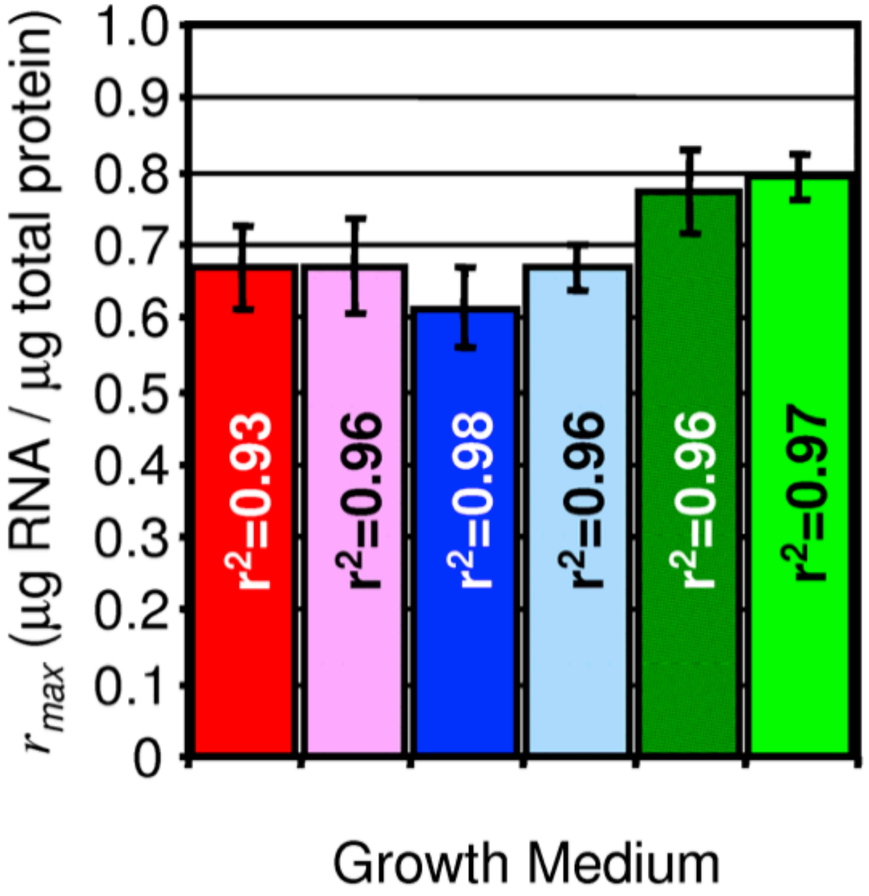


Strain / Medium	EQ2/EQ3 Chloramphenicol conc. (μM)				
	0	2	4	8	12
M63+glyc	●	2	4	8	12
M63+gluc	●	2	4	8	12
cAA+glyc	●	2	4	8	12
cAA+gluc	●	2	4	8	12
RDM+glyc	●	2	4	8	12
RDM+gluc	●	2	4	8	12

Scott et. al (2010)

The value of $\phi_{\max}$ is nutrient independent





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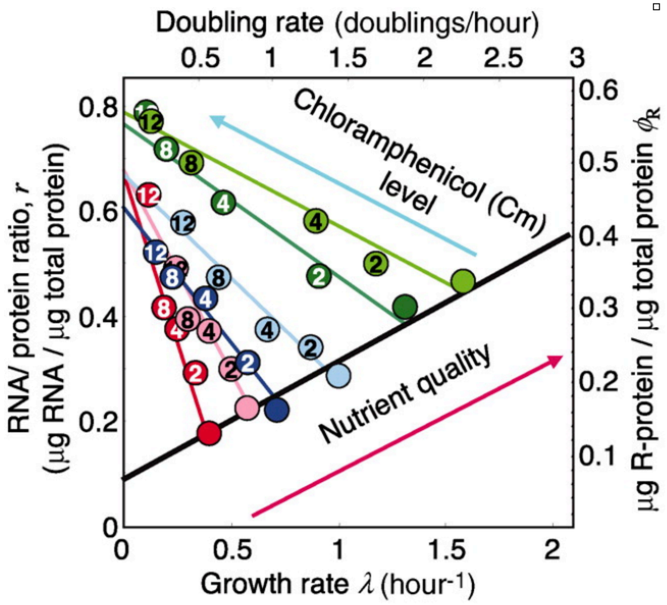
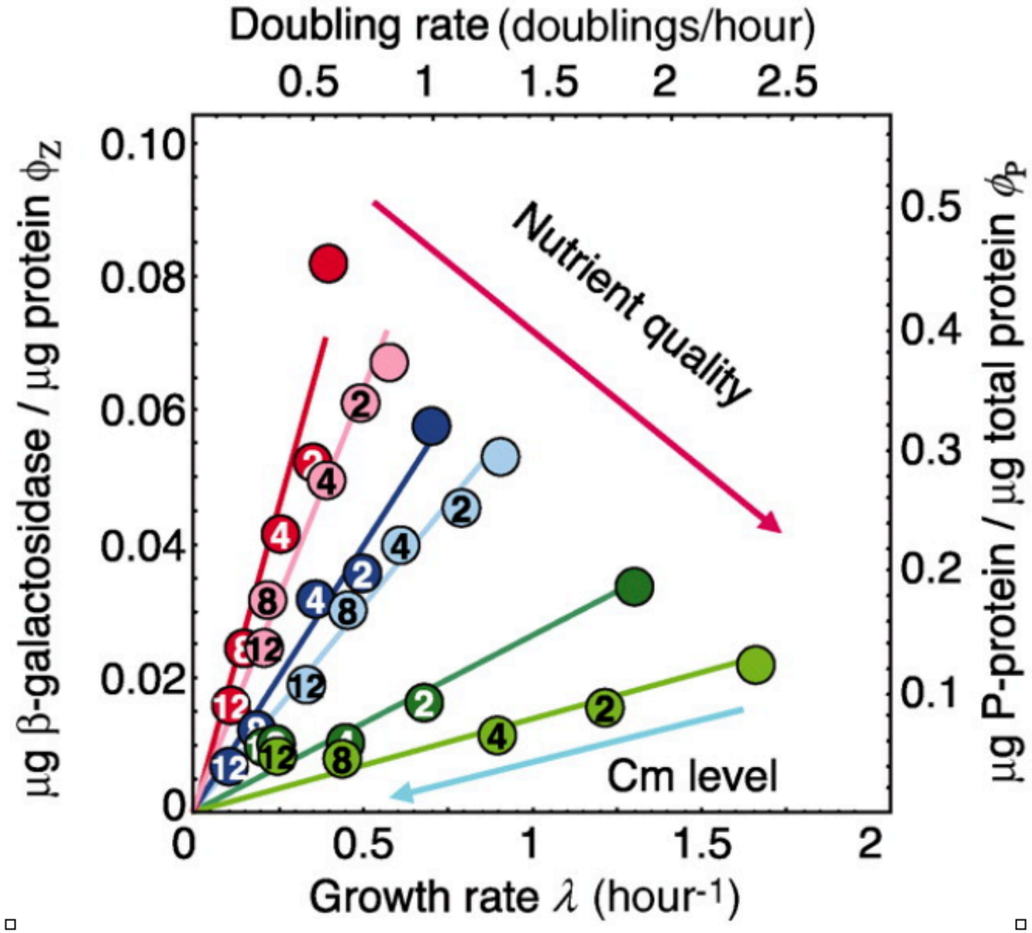
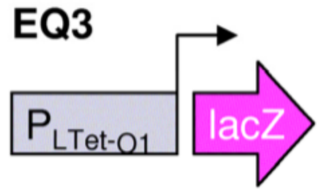
Scott et. al (2010)

Constitutively expressed (~unregulated) proteins have the inverse dependency of ribosomes







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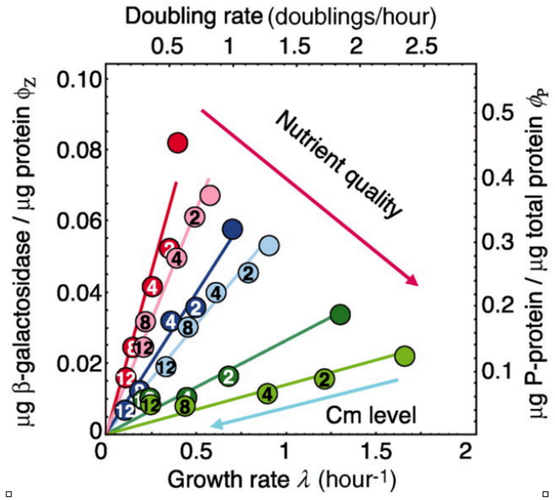
Scott et. al (2010)

Negatively regulated proteins are constant



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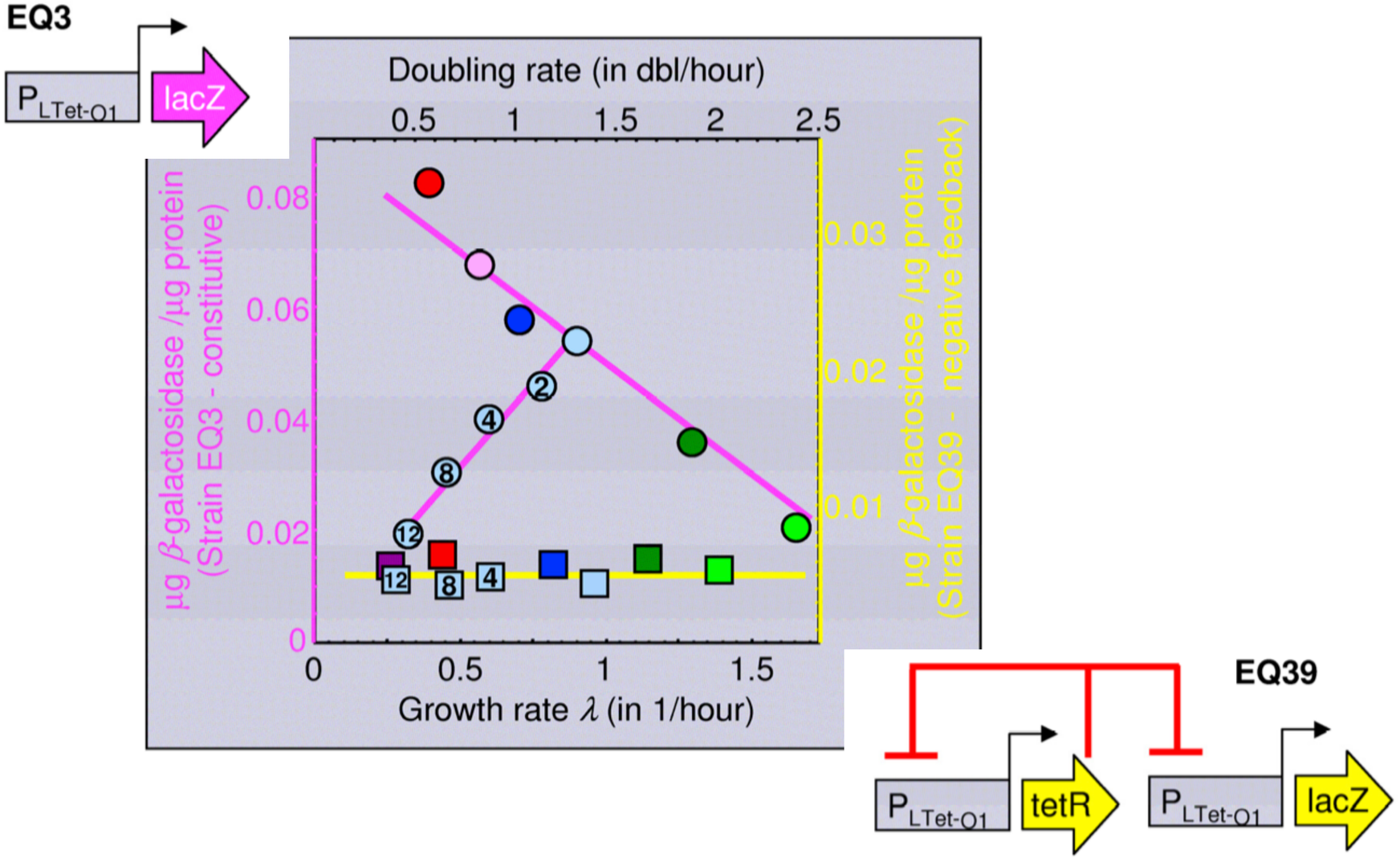

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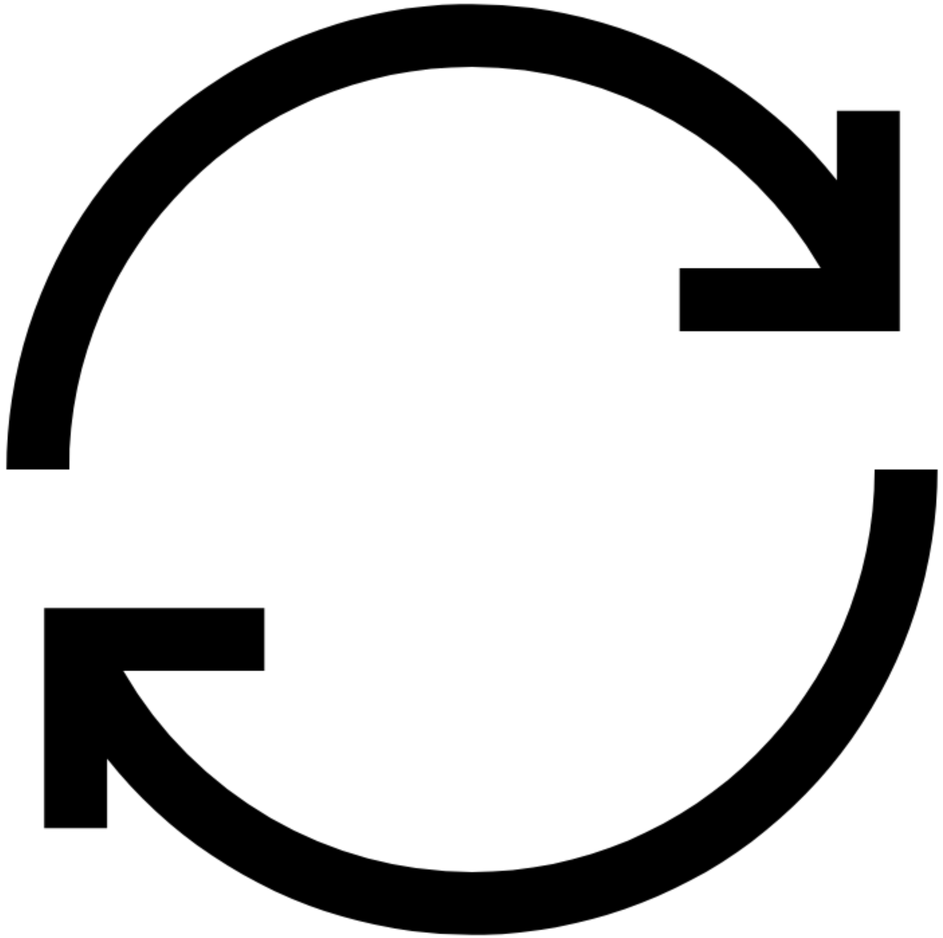

References

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Scott et a., Science 2010