Coordination of Cell Growth and Cell Division

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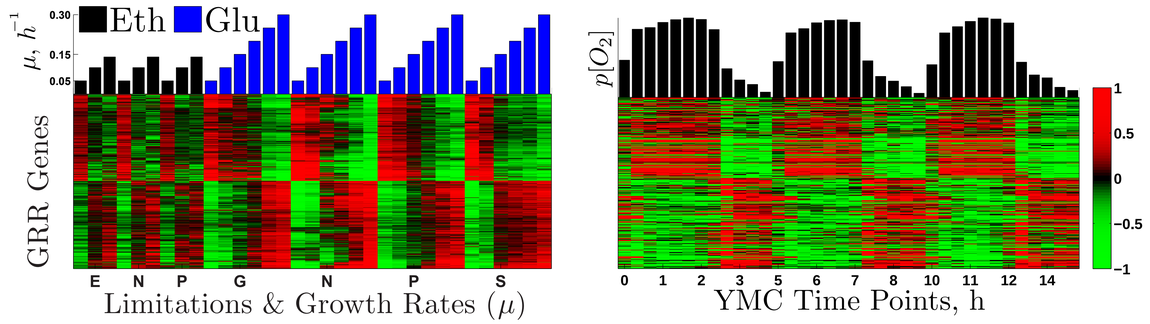
Genes with Common Growth Rate Response are YMC periodic

At least 25% of the genes in the genome of budding yeast increase or decrease in expression monotonically with the growth rate (μ), independent of the nutrient limitation and the carbon source (Slavov and Botstein, 2011).

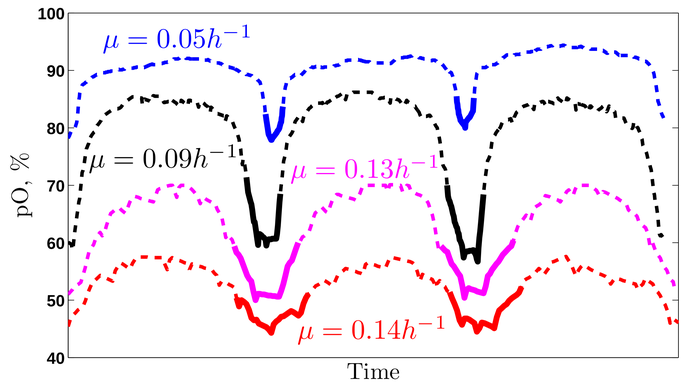


Coupling of the Growth Rate Response and the YMC Left panel: Mean centered expression levels of genes with universal growth rate response. The first 9 columns (black bars) correspond to ethanol carbon source and limitations on ethanol (E), nitrogen (N) and phosphorus (P). The next columns (blue bars) correspond to glucose carbon source and limitations on glucose (G), nitrogen, phosphorus and sulfur (S). Right panel: Mean-centered expression levels of the same genes (clustered using the data from the left panel) in the yeast metabolic cycle *YMC*.

Overrepresented Gene Ontology (GO) Terms

Positive Growth Rate Response		Negative Growth Rate Response	
ribosome biogenesis	1×10^{-33}	vacuolar protein catabolic process	9×10^{-39}
cellular biosynthetic process	8×10^{-31}	stress response	1×10^{-33}
regulation of translation	2×10^{-23}	autophagy	9×10^{-28}
mitochondrial translation	2×10^{-16}	cell differentiation	1×10^{-7}

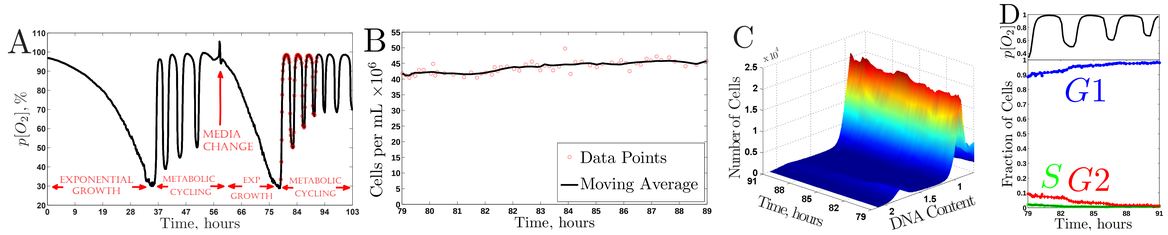
Metabolic Cycling across Growth Rates



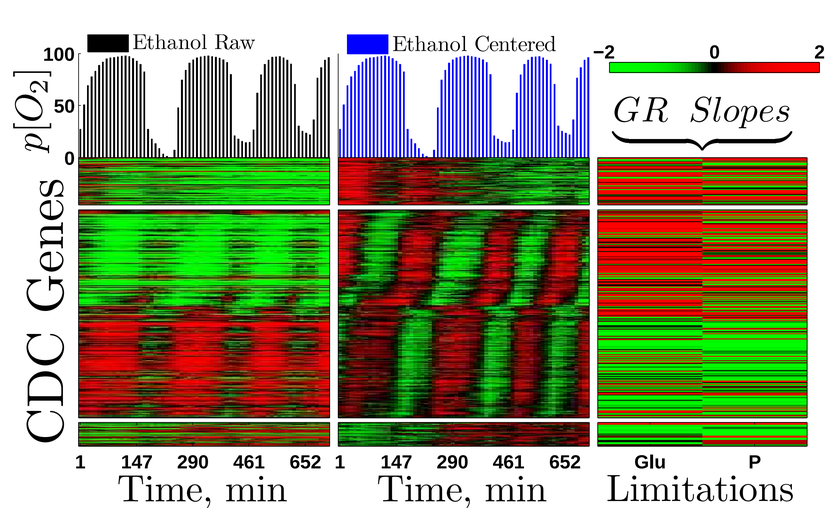
Changes in the *YMC* with Growth Rate. Three metabolic cycles are shown at multiple growth rates (μ). All periods are scaled to be the same for emphasizing changes in the *relative* durations of the *YMC* phases (Slavov and Botstein, 2011).

Metabolic Cycling without Cell Division Cycling

YMC reflects a growth cycle during the *G1/G0* phase of the cell division cycle (CDC). The cycling of genes annotated to the CDC in non-dividing cells can explain the growth-rate (GR) slopes of these genes in asynchronous cultures, thus reinforcing the relevance of the cell growth cycle to single cells from asynchronous cultures (Slavov *et al*, 2011, 2012).



Oxygen, Biomass and DNA Content (A) Oxygen consumption. The culture was sampled at the positions indicated by red circles (B) Cell density at each of the sampled points (C) Distribution of DNA Content (D) Fraction of cells in the CDC phases.



Expression of CDC Genes The left panels show expression levels relative to the reference (glucose limitation at $\mu = 0.25h^{-1}$), the middle panels shows the same data centered to mean zero and the right panels show the growth rate (GR) slopes of the corresponding genes in asynchronous cultures limited on either glucose (Glu) or phosphate (P).

References

Slavov N. and Botstein D. (2011) Coupling among Growth Rate Response, Metabolic Cycle and Cell Division Cycle in Yeast, *Mol. Biol. Cell*

Slavov N., Macinskas J., Caudy A., Botstein D. (2011) Metabolic Cycling without Cell Division Cycling in Respiring Yeast, *PNAS*

Slavov N., Airoldi E.M., van Oudenaarden A., Botstein D. (2012) A Conserved Cell Growth Cycle Can Account for the Environmental Stress Responses of Divergent Eukaryotes, *Mol. Biol. Cell*, 23