Math 376 Research Project

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Preface

TODO blah blah crap.

TODO source for unstructured vs. structured.

There are two approaches to modeling microorganism populations: structured, and unstructured. Structured models are, loosely, stoichiometric. They track real, measurable quantities and generally tightly couple the mathematics with the known mechanics of cell biology. Unstructured models, comparatively, operate at a higher level of abstraction. They are tailored regressions attempting to fit observed patterns of

Frankly, I think unstructured models are dull, as in they are uninteresting, and weak, in that they have limited predictive power. Hence, in this paper, I will attempt to keep to a structured approach whenever possible.

Monod's equation

$$\begin{aligned}
\frac{\dot{B}}{B} &= \mu_{max}\frac{S}{S_{half}+S} \\
B &\equiv cellmass \\
\mu_{max} &\equiv \text{maximum specific growth rate in B} \\
S &\equiv \text{concentration of limiting growth factor} \\
S_{half} &\equiv \text{half-max growth factor concentration}
\end{aligned}$$

Monod's equation is an empirical relation which describes the growth of microorganisms limited by a single nutrient (or substrate). It has been shown to have good agreement in the lab, and variations on it (with additional parameters) remain popular.

Effects of waste products

The effects of metabolic waste products are complicated.

Single population - lactic acid bacteria

We assume substrate uptake to obey Monod's equation; this is reasonable, as sugars are transported across the cell membrane by embedded enzymes. We further assume

Single population - yeast

Main difference from bacteria is aerobic respiration; respiration is considerably more efficient than fermentation pathways, with few byproducts. However the rate of respiration is limited by the availability of O~2. Oxygen has low solubility in water at near room temperatures, so yeast will quickly deplete initial stores of oxygen in a growth burst, then adopt a hybrid metabolic approach.