



Figure 6.15. Prediction of transient response in a continuous-flow system to perturbations in limiting substrate concentration or flow rate. Note that the predictions are not fitted to the data; predictions are completely a priori. (a) Transient glucose concentration in response to step change in glucose feed concentration from 1.0 to 1.88 g/l in anaerobic continuous culture of *E. coli* B/r at dilution rate of 0.38 h^{-1} ; ● and ▲, results of two duplicate experimental runs; solid line, computer prediction. (b) Transient glucose concentration in response to step change in dilution rate from $D = 0.16$ to $D = 0.55 \text{ h}^{-1}$; ● and ■, results of two duplicate experimental runs; solid line, computer prediction. (With permission, from M. M. Ataai and M. L. Shuler, *Biotechnol. Bioeng.* 27:1051, 1985, and John Wiley & Sons, Inc., New York.)

Solution When measuring the concentration of A , P , and S^* , the natural units are grams per liter of reactor volume. These are extrinsic concentrations. The total biomass concentration will be

$$X = A + P + S \approx A + P \quad (\text{a})$$

since the internal concentration of S will be low [$< 0.001(A + P)$]. By considering S^* and S separately, transients in S can be captured. However, these transients will be fast in comparison to changes in A and P . The Monod and other unstructured models assume an instantaneous equilibrium between S^* and S .

A number of kinetic descriptions would be defensible. However, let us assume the following pseudochemical equations:



where α_1 g of S is consumed to make 1 g of A plus by-products; the reaction requires both A as a “catalyst” and S for building blocks. Similarly, for P ,



where P is formed reversibly in this parallel reaction requiring A as the catalyst, and α_2 is a stoichiometric coefficient between the monomer S and the polymer P (g · S consumed/g · P formed).