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ABSTRACT A mathematical model for the regulation of induction in the lac operon in Escherichia coli is presented. This model takes into account the dynamics of the permease facilitating the internalization of external lactose; internal lactose; beta-galactosidase, which is involved in the conversion of lactose to allolactose, glucose and galactose; the allolactose interactions with the lac repressor; and mRNA. The final model consists of five nonlinear differential delay equations with delays due to the transcription and translation process. We have paid particular attention to the estimation of the parameters in the model. We have tested our model against two sets of beta-galactosidase activity versus time data, as well as a set of data on beta-galactosidase activity during periodic phosphate feeding. In all three cases we find excellent agreement between the data and the model predictions. Analytical and numerical studies also indicate that for physiologically realistic values of the external lactose and the bacterial growth rate, a regime exists where there may be bistable steady-state behavior, and that this corresponds to a cusp bifurcation in the model dynamics.

KEYWORDS: lactose, lactose operon, feedback regulation, feedback, data, experiment, system, nonlinear, differential equation, model