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The fundamental goal of molecular cell biology is to understand how the life of a cell is determined by the information encoded in its genome. In principle, we know how this information is translated into functional proteins that carry out most of the interesting chores in a living cell. But to make a firm connection between molecular events and cell behavior involves many challenging problems in nonlinear dynamics and computational cell biology. A nice example is the cell cycle: the sequence of events by which a growing cell duplicates all its components and partitions them more-or-less evenly between two daughter cells. The molecular mechanism that controls DNA synthesis and nuclear division is so complex that its behavior cannot be understood by casual, hand-waving arguments. By translating this mechanism into differential equations, we can analyze and simulate the behavior of the control system, comparing model predictions to the observed properties of cells. This approach is generally applicable to any complex gene-protein network that regulates some behavior of a living cell.

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