

Time and the laws of nature

Ilya Prigogine

Abstract

The first part of this paper gives a summary of the philosophy of nature and of the view on time that follows from recent fundamental theories on complex systems. This part is followed by an interview-style part on the implications of this view for consciousness.

1. Time and the laws of nature

Time enters Newtonian physics as well as in quantum mechanics, but in a particular way. Indeed, the basic equations are time reversible. In other words, they remain invariant when $+t$ is replaced by $-t$. Moreover, they correspond to a deterministic description. Once the "state" of the system is given at some time t we can calculate this state for arbitrary times t both in the future and in the past. However everywhere around us we observe irreversible processes in which past and future play different roles. This is true on the microscopic level (consider e.g. radioactivity) as well as on the macroscopic level studied in thermodynamics. There the central quantity is entropy which increases with time till the system has reached equilibrium. Time symmetry is broken. Therefore A. Eddington has called entropy the "arrow of time".

The first to note the conflict between the time reversible view of nature and the evolutionary view based on entropy, was Ludwig Boltzmann (1872). Boltzmann looked for a microscopic dynamical interpretation of irreversibility. But this led to difficulties. Suppose that we invert the velocities of all molecules. This system would then go into its own past and entropy would decrease. To counter this argument Boltzmann added two ingredients: (a) "events" are determined not only by the laws of dynamics but also by initial conditions, (b) probabilistic reasoning; the probability of each macroscopic state is obtained by