We investigated the kinetic properties of the hyperpolarization-activated inward current ($I_h$) of thalamocortical (TC) neurons. Recently, it was shown that this current is characterized by different time constants of activation and inactivation, which was in apparent conflict with the single-exponential time course of the current. We introduce here a model of $I_h$, based on the cooperation of a slow and a fast activation variable and show that this kinetic scheme accounts for these apparently conflicting experimental data. We also propose that following the combi-
cells. Moreover, for cat TC cells, spindle-like oscillations have also been found when enhancing \( I_h \). In this case, while increasing \( I_h \) strength, the following sequence of modes were observed: a hyperpolarized resting state when \( I_h \) is blocked, slow oscillations for weak values of \( I_h \), spindle-like oscillations for higher values of \( I_h \), and finally, a depolarized resting state for a further increase in the value of \( I_h \). This sequence was reversed by gradually decreasing the strength of \( I_h \).

A similar sequence of oscillatory modes can be seen...
oscillating and resting states, as seen experimentally by the experiments of Soltesz et al. The transition between these modes is achieved by increasing the maximal conductance of \( I_n \). The model therefore produces several modes very similar to those seen in TC cells, and the transitions between them.

**Conclusions**

The model of the hyperpolarization-activated inward current proposed here is based on the cooperation of two activation variables, and accounts for the unusual kinetic properties of this current. This model also preserves the slow components of activation of this current. Different types of oscillating behavior are seen when combining this model of \( I_n \) with known models of two other currents of TC neurons, namely \( I_f \) and \( I_{K_r} \). Among these, are slow oscillations and spindle-like oscillations. The latter can be obtained only when considering the double activation model for \( I_n \), which suggests that the slow components of the activation of \( I_n \) might be essential for reproducing spindle-like oscillatory behavior.

**References**