Despite decreases in the level of brain metabolism in moderate hypothermia [7, 11, 15], many biochemical and electrophysiological measures of nerve cell function remain stable until cooling reaches 25°C or below. Thus, the membrane potential of hippocampal neurons shows almost no change until 20°C [12] and Na\(^{+},K^{+}\)-ATPase even increases slightly over this temperature range [1, 11]; intracellular Ca\(^{2+}\) levels in transient cooling show no significant changes [1]. However, decreases in temperature to below 34°C lead to sharp decreases in oxygen consumption by brain tissues [4, 7, 11]. This is evidence for a decrease in the rate of high-energy processes, which may be associated with the functions of active perception, given that mammals completely lose consciousness at temperatures of 25–26°C [7, 9].

The present report describes our studies of the spike activity of cortical neurons, directed to identifying the most hypothermia-sensitive parameter. Special attention was paid to cellular responses to glutamate, which is the main excitatory transmitter in a variety of cortical connections [16].

Experiments were performed on parietal cortex slices from guinea pigs weighing 200–250 g. Slices of thickness 500 \(\mu\)m were prepared from longitudinal blocks of cortex using a SVL vibrotome (World Precision Instruments, USA). The incubation chamber in which slices were placed consisted of two sections with independent flows of Ringer–Krebs solution saturated with gas mix (95% O\(_2\), 5% CO\(_2\)) and containing 124 mM NaCl, 2.4 mM CaCl\(_2\), 1.3 mM MgSO\(_4\), 5 mM KCl, 1.25 mM KH\(_2\)PO\(_4\), 26 mM NaHCO\(_3\), and 10 mM glucose (pH 7.4). The flow rate was 1.5–3 ml/min. The medium was prewarmed using a U1 thermostat (VEB, Germany) and a thermostating device based on a Peltier element (Biopriborov, Russia) was used for fine temperature control. The temperature of the medium in the experimental section of the chamber was monitored continuously with an electronic thermometer (NIKAS, Russia).

Prepared sections were incubated for 1 h at room temperature, after which the solution temperature was increased to 32–34°C. This temperature was maintained throughout the experiment for control testing of nerve cell spike activity. Solution in the experimental section was cooled to 20–24°C at a rate of 2°C/min, subsequent normalization of the temperature being at the same rate. The entire hypothermic cycle thus lasted no more than 10 min. The temperature was increased to 36–38°C. Depending on the duration of spike activity recording, neurons were tested either over the whole temperature range or through a temperature change of a few degrees.

Extracellular recordings of spike activity were made and glutamate was applied by iontophoresis using three-channel glass microelectrodes with a total tip diameter of 7.4–8.0 \(\mu\)m. The recording channel and the channel used for monitoring the effects of the phoresis current were filled with 3 M NaCl. The third channel contained 1 M sodium...
glutamate solution (Sigma Chemical Company, USA) for iontophoretic application of glutamate close to the neuron being recorded. The glutamate phoresis current was 15–30 nA (the electrode was the negative pole), and phoresis lasted 1.0–1.5 sec. Glutamate was applied every 12 sec during cooling and warming, and the temperature of the solution was recorded simultaneously. The holding current between applications was 3–5 nA.

Neuron spike activity from the output of the amplifier was passed to an oscilloscope and recorded on magnetic tape for subsequent computer analysis. The mean background spike amplitude (peak to peak) was measured during the 2.8 sec before each application of glutamate, as was the maximum instantaneous mean frequency (using five successive bins of 200 msec). The maximum instantaneous mean frequency during glutamate application was taken as the evoked response. The significance of changes in measures of spontaneous and evoked activity was determined using non-parametric statistics [6].

RESULTS

The effects of temperature on the characteristics of spike activity were studied in 20 neurons of layer V of the parietal cortex. Cooling of the incubation medium consistently led to changes in two measures of spike activity: a decrease in spike amplitude and a decrease in the spontaneous spike frequency. Figure 1 shows an example of one such neuron which, starting from a temperature of 33°C, gradually decreased its spike amplitude from 218 ± 7 to 192 ± 5 μV at 24°C (Fig. 1, C). The change in spontaneous

![Graph showing changes in spike activity with temperature](image)