Chapter 16

NMDA Receptors as Voltage Sensors

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Abstract

The membrane potential is an essential parameter of a living cell. However, measurements of the membrane potential using conventional techniques are associated with a number of artifacts. Cell-attached recordings of the currents through NMDA receptor channels enable noninvasive measurements of the neuronal membrane potential. This approach overcomes the problem of a leak conductance introduced during intracellular sharp electrode recordings and whole-cell patch-clamp recordings. Here, we describe the procedures of using cell-attached recordings of NMDA receptor channels to measure the true membrane potential.

Key words NMDA receptor, Patch-clamp, Cell-attached, Membrane potential

1 Introduction

Electrical potential across the cytoplasmic membrane, or a resting membrane potential (E_m), is a fundamental property of a living cell. In neurons and other excitable cells, the resting membrane potential plays a key role in electrogenesis by setting a default state of the voltage-gated and transmitter-activated ion channels of the plasma membrane and it acts as a driving forceDriving force for transmembrane co-transporters of ions and other molecules. Therefore, knowledge of the E_m values is critical for understanding the excitable cell functions. However, the measurement of the E_m values is not a trivial task, as each measure introduces some amount of error. Conventional approaches for the E_m measurements are the intracellular recordings using sharp electrodes and whole-cell patch-clamp recordings. Yet, these approaches may introduce strong errors in E_m measurements through the (1) alterations in the ionic composition of the intracellular milieu (dialysis problem) and (2) introduction of a leak conductance at the contact between the electrode and a cell membrane, which attains 500 MOhms during intracellular recordings and several GOhms during whole-cell recordings (leakage problem). Both the artifacts are more

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