Toxic!
The role of scorpion toxin and BK channels in the Tobacco Hawkmoth

Introduction

Metamorphosis is an extraordinary process in which a caterpillar evolves into a completely different creature. During metamorphosis slow-twitch muscles in the caterpillar become fast-twitch muscles in the moth, coinciding with an explosive increase in BK channels. Using a scorpion toxin that targets these channels, the nature of change from posture to flight muscle can be investigated.

BK Channel Function

Potassium channels in muscle cells are critical to the mechanism of the action potential. Action potentials generate waves of electrochemical activity, carrying electrical signals through muscle cell membranes. BK channels are opened in response to an increase in intracellular calcium, which regulates the excitability of cells. Removal of K⁺ ions through the BK channel causes the cell membrane to repolarize. K⁺ ions flow through the central portion of the channel and are guided by a series of negatively charged oxygen atoms. The efflux of K⁺ ions repolarizes the membrane potential, readying the cell for a subsequent action potential.

Abstract

In the Tobacco Hornworm, the muscle under study is a posture muscle that has a slow recovery (repolarization) rate, and is classified as “slow-twitch”. Metamorphosis transforms this muscle into a flight muscle requiring a fast repolarization rate, becoming a “fast-twitch” muscle. The repolarization rate of these muscle cells is directly linked to the muscle’s rate of contraction, corresponding with an explosive increase in the number of the Ca²⁺-gated K⁺ channels (BK) in these muscles. The Chinese scorpion toxin BmP09, from Buthus martensi Karsch, will be used to identify the BK channel as responsible for the change. This toxin binds specifically to the BK channel, slowing repolarization. Studying the repolarization rates can help determine if the BK channel is involved in the transformation from posture to flight muscle.

Metamorphosis

As the caterpillar undergoes metamorphosis, its slow-twitch back postural muscles become fast-twitch wing muscles. The hypothesis being tested is that an increased number of BK channels may cause the muscles to repolarize faster, allowing the muscles to contract more rapidly.

Toxin

The Chinese scorpion toxin BmP09 paralyzes prey by binding to the extracellular domain of the BK channel, preventing the flow of K⁺ ions out of the cell. The inability of the cell to efflux K⁺ ions prevents the cell from repolarizing as quickly and stops the muscle from contracting, resulting in paralysis.

Flying Away

Further research using the BmP09 toxin to selectively bind to the BK channel can help positively identify this channel as the specific K⁺ channel involved in the metamorphosis of the posture muscle in the Tobacco Hornworm to a flight muscle in the Tobacco Hawkmoth.

Citations


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