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The Broad Biological Significance of Eicosanoids in Invertebrates

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Abstract

We present a brief sketch of the discovery of prostaglandins and other eicosanoids in human and veterinary biomedicine, and then comment on their significance in invertebrates, all reviewed in detail elsewhere. Here we bring out a few points. One, PG biosynthesis in insects follows a mechanism different from mammals. Two, insect systems are amenable to functional studies of specific genes operating in eicosanoid systems via RNAi and CRISPR-Cas9, which has accelerated understanding of genes involved in PG synthesis and in receptor-mediated actions. We suggest research into some model insect systems, particularly Drosophila melanogaster and the moth Spodoptera exigua, may lead to broadly useful insights into PG actions.

Keywords: Prostaglandins • Innate immunity • Prostaglandin • Immune response • Cyclooxygenase

Introduction

Von Euler was the first to label prostaglandins (PGs), despite a few prior papers on the subject [1]. In uterine smooth muscle preparations, He observed that substances in human and a few other species' sperm caused contractions in uterine smooth muscle preparations. Von Euler detected an acidic component in the sperm, which he termed prostaglandin since a portion of the sperm is produced in the prostate gland, as was typical in science at the time. Two more discoveries later, a new pharmaceutical business with incredible scope, comprehension, and biological relevance was born, with the knowledge being applied to critical concerns in human and veterinary care. The first was the determination of PG chemical structures [2], led by Professor Sune Bergström and his student, Bengt Samuelsson. A little later, British pharmacologist, John Vane, discovered that aspirin and aspirin-like drugs inhibit prostaglandin biosynthesis [3]. Bergström, Samuelsson and Vane shared the 1982 Nobel Prize in Physiology or Medicine “for their discoveries concerning prostaglandins and related biologically active substances”. Following it, there were other discoveries, new treatments, and a profound understanding of PG effects in humans and other mammals, all of which resulted in highly appreciated medical advancements.

PGs and related bioactive lipids are also found in the majority, if not all, invertebrate phyla. The purpose of this Commentary is to increase understanding of these chemicals by briefly discussing some of their invertebrate functions. The subject has been thoroughly examined, and we will not repeat their activities here [4-7].

In several invertebrate phyla, eicosanoids mediate numerous aspects of reproduction among PGs and related lipid-mediated processes. These molecules mediate critical innate immunity pathways in insects and a few other arthropods. They play a function in renal physiology, ovarian development, egg-laying behaviour, and hemocyte migration in insects, among other things.

Aside from their biological actions in invertebrates, research into invertebrate eicosanoid systems revealed new mechanisms. C20 polyunsaturated fatty acids are found in trace amounts in the tissues of terrestrial insects but not aquatic insects [7,8]. For these species, eicosanoid biosynthesis begins with hydrolysis of linoleic acid (LA; 18:2n-6) from membrane phospholipids, which is taken into elongation/desaturation pathways that lead to arachidonicacid (AA; 20:4n-6). S. exiguagenes encoding desaturases and elongases were found in their study on the topic, and silencing the genes resulted in significantly diminished immunological responses to bacterial infection. Drosophila melanogaster, a fruit fly, was the subject of their research [9] discovered a novel mechanism of PG biosynthesis based on a peroxidase, rather than a cyclooxygenase, it was later proven [10]. Similarly, based on a recent CRISPR-Case9 study, [11] reported that deletion of a gene encoding a PGE2 receptor leads to suppressed immunity and adult infertility. Non-self-recognition in insect immune systems tightly links to eicosanoid biosynthesis, in which HMGB1, a damage-associated molecular pattern, plays a crucial role in triggering eicosanoid signaling by activating PLA2 [12]. Eicosanoids are important players in the biology of invertebrates in general and we suspect some of their actions may attract a wide range of interest. 1. PG biosynthesis in insects follows a mechanism which is different from mammals. 2. Using RNAi and CRISPR-Cas9, functional studies of specific genes operating in eicosanoid systems can be performed in insect systems, which has accelerated understanding of genes involved in PG synthesis and in receptor-mediated actions.

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