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RESEARCH ARTICLE

Ooplasmic Segregation in the Zebrafish Zygote and Early Embryo: Pattern of Ooplasmic Movements and Transport Pathways

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Patterns of cytoplasmic movements and organization of transport pathways were examined in live or fixed zygotes and early zebrafish embryos using a variety of techniques. The zygote blastodisc grows by accumulation of ooplasm, transported to the animal pole from distinct sectors of ecto- and endoplasm at different speeds and developmental periods, using specific pathways or streamers. Slow transport (5 μm/min) occurs during the first interphase along short streamers, whereas fast transport (9.6–40 μm/min) takes place during the first cleavage division along axial and meridional streamers. Interconnections between streamers allow cargoes to change their speed and final destination. A similar sequence of events occurs during the following divisions. A complex network of microtubules and actin filaments in the endo- and ectoplasm appears to be involved in the transport of inclusions and mRNAs. Actin-dependent intermittent pulsations provoked high-speed back-and-forth movements of cytoplasm that may contribute to redistribution of organelles and maternal determinants. *Developmental Dynamics 239:2172–2189, 2010.*

Key words: ooplasmic segregation; early zebrafish development; cytoplasmic movements; zygote development; ooplasmic domains; zygote cytoskeleton; maternal mRNA localization and transportation

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INTRODUCTION

Ooplasmic domains are sectors of the egg cytoplasm that enclose organelles, cytoplasmic determinants, and cytoskeleton (Fernández and Olea, 1982, 1995; Bally-Cuif et al., 1998; Fernández et al., 1998, 2006). In many eggs, formation of these domains involves separation of yolk from the rest of the cytoplasmic components by a process called ooplasmic segregation. This process is essential to ensure normal embryonic development and occurs in the eggs of invertebrate and vertebrate organisms that exhibit mosaic or regulative development, respectively. In invertebrates, examples of such a segregation process are seen in the oligochaetes, which form conspicuous polar domains (Penners, 1922; Shimizu, 1982); leeches, which originate bizarre teloplasms (Whitman, 1878; Fernández and Olea, 1982); ascidians, which give rise to crescent-shaped domains (Conklin, 1905; Jeffery and Meier, 1983); nematodes and insects, which form germ plasm (Mahowald, 1962; Strome and Wood, 1983); as well as polychaetes and some molluscs, which form voluminous polar lobes (Wilson, 1904; Lillie, 1906). In vertebrates, an example is the formation of the embryonic disc, or blastodisc, that gives rise to most of the embryo in fishes, reptiles, and birds (Nelsen, 1953).

The zebrafish zygote is about 700 μm in diameter and consists of vitelloplasm, which contains yolk globules, and ooplasm. The ooplasm contains numerous organelles and forms three interconnected domains: a blastodisc at the top of the animal hemisphere, a layer of ectoplasm at the yolk cell periphery, and a network of endoplasmic lacunae in the yolk cell. Formation of these domains is initiated during oogenesis (Fernández et al., 2006; Lessman, 2009). The structure of this egg contrasts with that of other fishes such

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