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Pattern Formation in a Pentamerous Animal: Induction of Early Adult Rudiment Development in Sea Urchins

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Abstract

We investigated adult rudiment induction in the direct-developing sea urchin *Heliocidaris erythrogramma* microsurgically. After removal of the archenteron (which includes presumptive coelomic mesoderm as well as presumptive endoderm) from late gastrulae, larval ectoderm develops properly but obvious rudiments (tube feet, nervous system, and adult skeleton) fail to form, indicating that coelomic mesoderm, endoderm, or both are required for induction of adult development. Recombination of ectoderm and archenteron rescues development. Implanted endoderm alone or left coelom alone each regenerate the full complement of archenteron derivatives; thus, they are uninformative as to the relative inductive potential of the two regions. However, in isolated ectoderm, more limited regeneration gives rise to larvae containing no archenteron derivatives at all, endoderm only, or both endoderm and left coelom. Adult nervous system begins to develop only in the latter, indicating that left coelom is required for the inductive signal. Isolated ectoderm develops a vestibule (the precursor of adult ectoderm) and correctly regulates vestibular expression of the ectodermal territory marker *HeET-1*, indicating that the early phase of vestibule development occurs autonomously; only later development requires the inductive signal. Another ectodermal marker, *HeARS*, is regulated properly in the larval ectoderm region, but not in the vestibule. *HeARS* regulation thus represents an early response to the inducing signal. We compare *HeARS* expression in *H. erythrogramma* with that in indirect developers and discuss its implications for modularity in the evolution of developmental mode.


Keywords





induction; signaling; mesoderm; coelom; hydrocoel; vestibule; rudiment; modularity; skeletal patterning







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