Vertebrates, insects and planarians: different strategies to generate primary body axes with an orthogonal orientation

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The generation of organizing regions is central for the axial organization of higher organism. At the beginning of my talk I will introduce generative principles that allow organizer formation and compare the theoretically predicted mechanisms with some recent observations on the molecular-genetic level.
Higher organisms show a bilateral-symmetric organization of their bodies. This requires two pattern-forming mechanisms, one that is responsible for the organization of the antero-posterior and one for the dorsoventral axis. It is of obvious importance that these pattern-forming systems have an orthogonal orientation to each other. However, in vertebrates only a single organizer is usually assumed to exist, the Spemann-type organizer. How can a single organizer organize two orthogonal body axes?
Axis formation in evolutionary ancestral radial-symmetric animals is proposed to be the key to understand the more evolved bilateral-symmetric body patterning. A comparison of gene expressions reveals that the system that was organizing once the body of hydra-like ancestors evolved into the system that organizes the AP axis, especially the brain of present-day organisms. The ancestral hydra-type organizer surrounding the blastopore, based on the WNT-pathway, is proposed to be the missing second organizer. The trunk is an evolutionary later addition and its patterning follows different rules. Dorsoventral patterning requires an organizing region with a stripe-like extension, as given in the prechordal plate and notochord. Modelling revealed that the generation of such a solitary stripe-like organizing region is a subtle patterning problem that requires the cooperation of several pattern-forming reactions. As exemplified by vertebrates, insects and planarians, nature found very different solutions to realize this crucial step. In vertebrates the midline becomes posteriorly elongated by the relative movement of the organizer; the DV structures depend on the distance from this midline, not on the distance to the organizer as assumed in textbooks and in recent research papers. In contrast, in insects, the midline has from the beginning the full anteroposterior extension but becomes ventrally restricted by an inhibitory influence of a dorsal organizer. The different modes of midline formation are presumably the point of no return in the major divergence of the main evolutionary branches, protosomia and deuterostomia. These models allow an integrated view how early axes formation works in higher organisms, bring differences and similarities into an evolutionary perspective and resolve several controversially discussed issues.