

**Extended Data Figure 10 | Dorsoventral patterning and the evolution of bilaterian trunk neuroanatomy.** **a, b**, Schematic drawings of trunk neuroanatomy (nerve cords in blue) and expression of patterning genes in spiralian (**a**) and bilaterian (**b**) lineages. The overall location of patterning genes expression domains with respect to the dorsoventral axis and nerve cords is indicated by light green. In **a**, the red dashed squared expression of *pax6* and *pax3/7* in brachiopods indicates that these expression domains are only in the anterior region of the mantle lobe, not all along the trunk. Similarly, the red dashed squared expression of *nkx6* in rotifers highlights that this gene is only expressed posteriorly in the trunk. In **b**, the red dashed squared expression of *nkx2.1*, *nkx2.2*, and *nkx6* in Cnidaria indicates that these genes are expressed in the pharynx ectoderm. The red dashed squared expression of *nkx6* in *M. stichopi* shows that this gene is only expressed posteriorly. In the acoel *I. pulchra*, the red dashed squared expression of *nkx2.2* specifies that this gene is only expressed between mouth and copulatory organ. Red circles imply that a gene is not expressed in the trunk or is missing. Question marks

indicate that there are no available data about the expression of that particular gene. See Supplementary Table 2 and main text for references. Schematic drawings are not to scale and only represent approximate relative expression domains. **c**, Alternative scenarios for the evolution of the dorsoventral patterning and bilaterian nerve cords. In scenario A, the medially condensed nerve cords of vertebrates, arthropods, and annelids are homologous. Therefore, the dorsoventral patterning was lost multiple times both in lineages with medially condensed nerve cords (for example, the annelid *O. fusiformis*, cephalochordates, and tunicates) and in lineages with multiple nerve cords and diffuse nerve nets. In scenario B, which is supported by this study and is more parsimonious, the similarities in dorsoventral patterning and trunk neuroanatomies of vertebrates, arthropods, and some annelids evolved convergently. The diversity of nerve cord arrangements in nephrozoan lineages hampers reconstruction of the ancestral neuroanatomy for this group (question mark). Animal phylogeny is based on ref. 18.