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The Bicoid Gradient in the Drosophila Embryo: 3D Modelling with Realistic Egg Geometries

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Abstract : Segmentation of the early Drosophila embryo results from the dynamic establishment of spatial gene expression patterns. Patterning occurs on an embryo geometry which is a 'deformed' prolate ellipsoid, with anteroposterior and dorsal-ventral major and minor axes, respectively. Patterning is largely independent along each axis, but some interaction can be seen in the 'bending' of the segmental expression stripes. This interaction is not well understood. In this report, we investigate how 3D geometrical features of the early embryo affect the segmental expression patterning. Specifically, we study the effect of geometry on formation of the Bicoid primary morphogenetic gradient. Our computational results demonstrate that embryos with a much longer ventral than dorsal surface ('bellied') can produce curved Bicoid concentration contours which could activate curved stripes in the downstream pair-rule segmentation genes. In addition, we show that having an extended source for Bicoid in the anterior of the embryo may be necessary for producing the observed exponential form of the Bicoid gradient along the anteroposterior axis.

Keywords : Drosophila embryo, bicoid morphogenetic gradient, exponential expression profile, expression surface form, segmentation genes, 3D modelling
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