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A Clock and Wavefront Self-Organizing model explains somitogenesis in vivo and in vitro

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During mouse development, presomitic mesoderm cells synchronize Wnt and Notch oscillations, forming sequential waves that pattern somites. Classical somitogenesis models attribute these synchronizations to global morphogen gradients. However, increasing evidence suggests that they could arise in a self-organizing manner. Here, we introduce the Sevilletor, a novel reaction-diffusion system that serves as a framework to compare different somitogenesis hypotheses. Using this framework, we propose the Clock and Wavefront Self-Organizing model, the first somitogenesis hypothesis where phase waves are formed by a guided self-organizing process. Our analysis shows that this model can recapitulate the formation of multiple phase waves observed upon ectopic expansion of posterior gradients. Moreover, it can explain the formation of circular phase waves observed in explants that lack global signals. Finally, it provides a theoretical basis for understanding the excitability of mouse presomitic mesoderm cells and the changes in relative phase of Wnt and Notch observed during mouse somitogenesis.

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