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The Self-Made Puzzle: Integrating Self-Assembly and Pattern Formation Under Non-Random Genetic Regulation

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***Abstract*—** On the one hand, research in *self-assembling* systems, whether natural or artificial, has traditionally focused on pre-existing components endowed with fixed shapes. Biological development, by contrast, dynamically creates new cells that acquire selective adhesion properties through differentiation induced by their neighborhood. On the other hand, *pattern formation* phenomena are generally construed as orderly states of activity on top of a continuous 2-D or 3-D substrate. Yet, again, the spontaneous patterning of an organism into domains of gene expression arises within a multicellular medium in perpetual expansion and reshaping. Finally, both phenomena are often thought in terms of *stochastic* events—whether mixed components that randomly collide in self-assembly, or spots and stripes that crop up unpredictably from instabilities in pattern formation. Here too, these notions need significant revision if they are to be extended and applied to embryogenesis. Cells are not randomly mixed but pre-positioned where cell division occurs. Genetic identity domains are not randomly distributed but highly regulated in number and position. In this work I present a computational model of *programmable* and *reproducible* artificial morphogenesis that integrates self-assembly and pattern formation under the control of a nonrandom gene regulatory network. The specialized properties of cells (division, adhesion, migration) are determined by the gene expression domains to which they belong, while at the same time these domains further expand and segment into subdomains due to the self-assembly of specialized cells. Through this model I also promote a new discipline, *embryomorphic engineering* to solve the paradox of "meta-designing" decentralized, autonomous systems.