

A Bit on Programmable Matter.

New concepts in science and technology sometimes sound like band names.

"Programmable matter," however, isn't the product of a bottle of whiskey and garage fumes, but a mega-convergence of biology, chemistry, materials science, information theory, nanotechnology, and various fields of engineering. Such breadth precipitates an era of science that dissolves walls between traditional scientific and engineering disciplines. Imagine being able to grow our houses or morph our appliances to better fit our needs, space, or even aesthetic. Or even just imagine being able to make 3D prototypes of new products by telling a blob of components how to look and function.

To clarify, let's step back 30 years and consider, for example, a LEGO brick - when the toys were passive and simple (and well-organized if they were mine) and we aspired to build a house, not a walking T-Rex. To construct the house, you might start with a wall, then a room, then another room, some stairs, etc., piecing each individual block together into shallow hierarchies of subassemblies, until you arrived at your grand, omniscient plan. But no matter how long you'd be gone at summer camp, your LEGO house was never going to change, compute, or harness other LEGOs from the environment to increase its real estate. This is still how most man-made objects are still made today, using assembly style manufacturing with a top-down approach.

Now let's step back billions of years and consider nature's building blocks. With relatively few components (4 nucleic and 20 amino acids) biology builds its entire array of complex organisms. As opposed to our LEGOs, the developmental plans (or, more aptly, lack thereof) for scalable living structures, robustness, diversity, and evolution are encoded into the actual blocks and shaped by the environments in which the blocks exist. That is, the *program* is inherent to the pieces. Bottom-up design and assembly (growth) from genotype to phenotype is nature's way and it is the key to programmable matter.

Programmable matter is thus the notion of embedding logic and current state into tiny components (and large assemblies thereof) that can be programmed to change their physical properties based on user input or autonomous sensing. Just as biological systems evolve from complex interactions and environmental embeddedness of a handful of components, the materials made out of programmable matter will also conform to higher level algorithms that require them to process information, communicate, self-assemble, and react on demand and in real-time. Essentially the goal is to develop tiny computers, at the nano-scale, to replace our current (LEGO-like) tools for manufacturing. In concert with this we will need to apply algorithmic theories of growth and form and computational models derived from (but more mathematically tractable than) nature's example to drive the interactions of these reactive components. We need physical science research to better understand the flow of materials and energy throughout natural processes to new nanotechnology/engineering practices that can create and organize billions of synthetic components spatially and computationally.

"Programmable matter" may sound like unrelated words, paired together for impact, but let's remember that 60 years ago "personal computer" and "genetic engineering" weren't even on the roster.