

THE DOMESTICATION OF BIOTECHNOLOGY

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Fifty years ago in Princeton, I watched the mathematician John von Neumann designing and building the first electronic computer that operated with instructions coded into the machine. He knew that his invention would change the world. He understood that the descendants of his machine would dominate the operations of science and business and government. But he imagined computers always remaining large and expensive. He failed to foresee computers growing small enough and cheap enough to be used by housewives for doing income-tax returns or by kids for doing homework. He failed to foresee the final domestication of computers as toys for three-year-olds.

What has this story of von Neumann's computer and the evolution of computer games to do with biotechnology? Simply this, that there is a close analogy between von Neumann's vision of computers as large centralized facilities and the public perception of genetic engineering today as an activity of large pharmaceutical and agribusiness corporations. I see a bright future for the biotechnical industry when it follows the path of the computer industry, the path that von Neumann failed to foresee, becoming small and domesticated rather than big and centralized.

I recently spent a happy day at the Philadelphia Flower Show, the biggest flower show in the world, where flower-breeders from all over the world show off the results of their efforts. I have also visited the Reptile Show in San Diego, an equally impressive show displaying the work of another set of breeders. Philadelphia excels in orchids and roses; San Diego excels in lizards and snakes. Every orchid or rose or lizard or snake is the work of a dedicated and skilled breeder. There are thousands of people, amateurs and professionals, who devote their lives to this business. Now imagine what will happen when the tools

of genetic engineering become accessible to these people. There will be do-it-yourself kits for gardeners who will use genetic engineering to breed new varieties of roses and orchids. Also kits for lovers of pigeons and parrots and lizards and snakes, to breed new varieties of pets.

Genetic engineering, once it gets into the hands of housewives and children, will give us an explosion of diversity of new living creatures, rather than the monoculture crops that the big corporations prefer. New species will proliferate to replace those that monoculture farming and industrial development have destroyed. Designing genomes will be a personal thing, a new art form as creative as painting or sculpture. Few of the new creations will be masterpieces, but all will bring joy to their creators and variety to our fauna and flora.

The final step in the domestication of biotechnology will be biotech games, designed like computer games for children down to kindergarten age, but played with real eggs and seeds rather than with images on a screen. Playing such games, kids will acquire an intimate feeling for the organisms that they are growing. The winner could be the kid whose seed grows the prickliest cactus, or the kid whose egg hatches the cutest dinosaur. These games will be messy and possibly dangerous. Rules and regulations will be needed to make sure that our kids do not endanger themselves and others.

If domestication of biotechnology is the wave of the future, five important questions need to be answered. First, can it be stopped? Second, ought it to be stopped? Third, if stopping it is either impossible or undesirable, what are the appropriate limits that our society must impose on it? Fourth, how should the limits be decided? Fifth, how should the limits be enforced, nationally and internationally? ■

