



A CRITICAL INFLECTION POINT:  
THE NEW MOLECULAR TECHNOLOGIES, HEALTHCARE,  
AND ECONOMIC DEVELOPMENT IN ARIZONA

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**A**S I WAS GETTING READY TO GIVE THIS TALK, IT STRUCK ME that we are approaching what I would term a critical inflection point in the evolution of our global society. Inflection points occur when new discoveries and advances in our understanding coincide in some meaningful way with a given set of social, cultural, economic, and historical circumstances, allowing us to glimpse new opportunities. Admittedly sometimes these concurrences are not constructive or may at times even be negative, but the outcomes of the transition I am considering are certain to be positive and to have a profound impact on both our well-being and prosperity.

For thousands of years human beings have developed technologies derived essentially from rocks, plants, metals, and animals. We have mastered the manufacture of silicon for electronics from rock, mined coal from the detritus of dead plants, farmed live plants for food, and dug up the remains of dead animals in the form of oil. For millennia we have manipulated materials found in nature through sometimes crude technologies to produce useful products like gasoline, tools, and pharmaceuticals. We have used

science to understand the human body and invented ways to repair it in much the same way one would repair a broken machine: engineering our way around the problem with devices, altering the physical architecture of the body, and rerouting plumbing to make it work more efficiently.

But at this stage in our evolution we are unequivocally in the midst of a transition away from that dependence on rocks, plants, metals, and animals. Within the past twenty-five years, we have acquired the ability to manipulate the basic building blocks of life—molecules and DNA—making healthcare in the future a design problem instead of a construction problem. At this point already we can reroute cells in any direction for any purpose. This kind of molecular manipulation is only in its earliest stages, but holds unprecedented opportunities for human health and well-being. Our more sophisticated understanding of biological and chemical processes at the genetic and molecular levels signals a new relationship to nature, and the new molecular technologies signal the evolution of entire new industries.

At ASU there is a group working toward engineering a photosynthetic replicant—a machine that operates on the principles of photosynthesis but, more importantly, actually replicates the basic chemistry of the molecules and the crystalline structure inside a given plant. Through genetic engineering, molecular engineering, nanotechnology, and systems development, it is now possible to produce energy in the form of hydrogen from a machine using the same materials and mechanisms used in nature. Research of such complexity at this scale would have been impossible to conceive twenty years ago, and impossible to accomplish five years ago, but the current inflection has made it practicable within five years.

In another lab at the university another researcher is engineering new organisms—new life forms made from combining specific attributes found in different microorganisms. By taking the desired characteristics of organism A and merging them with organism B, he can construct organism X. The organism X now being developed will consume carbon dioxide out of the atmosphere at thousands of times the body weight of the organism. Not so long ago people who worked on this kind of science were considered dangerous, but now they are chaired professors at major research institutions.

For the fields of medicine and healthcare the implications of our new understanding of nature at the molecular level are vast, and however one may conceive the practice of medicine today, twenty years from now that conception will be hopelessly dated. Medicine in the near-term will become increasingly personalized—based on an individual's genetic makeup and personalized for that individual—and treatments and procedures will be performed with tools sufficiently precise to alter molecules and DNA in ways uniquely beneficial to each individual: you, your son, your daughter, your aging parent. Currently treatments are standardized and designed to apply to the largest percentage of people afflicted. As things stand today, if you are not exactly like the fifty million people comprising the

broad majority in responding to the generic tool designed for a given illness or condition, you are simply out of luck.

This inflection point signals greatly enhanced efficacy in healthcare. Sophisticated diagnostic tools and more effective treatments that solve more problems for more people are not only efficient, they help drive the economy forward, and this in turn enhances the overall quality of life. Enhanced quality of life means everybody gets a better than average chance to be healthy and free from untreatable illness. In terms of economic development and competitiveness, personalized medicine and the research enterprise associated with it could easily far exceed the current 18 to 20 percent of the overall economy attributed to healthcare.

**A**T THIS CRITICAL JUNCTURE ARIZONA HAS AN OPPORTUNITY to transform itself into one of the important centers for discovery and innovation in the biosciences and biotechnology and healthcare, one of the places whose name can become synonymous with biological discovery and innovation in much the same way that Pittsburgh and steel were synonymous many decades ago. We have an opportunity in Arizona to leverage a well-established and well-organized economic base: healthcare. Despite the competition we must leverage healthcare and bring clinical practice together with our evolving knowledge base, and find new ways to combine these twin assets to achieve two simultaneous goals. The first goal is to improve the quality of life as a consequence of enhanced healthcare. A corollary goal is spur economic development.

Opportunities to improve the quality of healthcare and promote economic development such as these will not recur in a generation or even a lifetime. There is much at stake, and now is the time to commit our resources to advancing this transformation in the life science and its clinical applications. Just as physics and the physical manipulation of rocks, plants, metals, and animals have been the economic impetus for the past 150 years, the life

sciences will become and remain the principal economic drivers for the next several decades, if not far longer. Not without justification is the twenty-first century being termed the “Century of Biology.”

It is important to note, however, that many other cities and regions have been engaged in exploration in the biosciences and biotechnology and their applications in healthcare. The gun for this race was shot off sometime back between 1982 and 1986. A number of regions have thirty laps on us, and they are moving fast. In order for us to be competitive we will somehow have to leapfrog to a vanguard position, something that can only happen when a solid foundation for success is in place. Such a foundation would require massive infrastructure investment: state-of-the-art research facilities—laboratories, supercomputer centers, and top-notch hospitals—and close interaction between scientists and health care providers. Arizona has a long road ahead to reach the infrastructure capacity necessary for the scale of this endeavor.

We must embrace the spirit of collaboration because the challenges are steep and our resources are limited. When compared with other states, Arizona has few medical schools, major hospitals, or research institutes and only a handful of universities. The collaboration between the University of Arizona and ASU in the establishment of a new medical school in Phoenix is an important step in the right direction, but we must think in larger terms, and leverage our strengths through collaboration nationwide with universities and institutes that are more advanced in their accomplishments in this sector at this juncture.

Arizona is home to world-class research institutes: TGen, the Biodesign Institute at ASU, and BIO5 at the University of Arizona represent important efforts to leapfrog ahead of the competition. Yet despite their significance, we will need many more enterprises of this caliber because, quite plainly,

not all of them will succeed to the same degree. If Arizona is to capture dominance in the fields of molecular and DNA manipulation, we must be willing to take risks and deploy multiple strategies. If we are to succeed we must accept the fact that some enterprises will be winners, and others will be losers.

**I**NFLECTION POINTS SUCH AS THIS ARE RARE, AND GIVEN the cost it is impossible to avoid skepticism and uncertainty. We are in the critical early stages of the advancement of a sector critical to the well-being of human society and crucial to the economic development of the region. At this stage there is everything to win and everything to lose in the effort to capture dominance in molecular and DNA manipulation, but we must we must maintain our stride if we are to succeed.