# Bio-Nanoprinting: Digitizing the Language of Life

In the October 2012 issue of *Trends*, we discussed NANOPRINTING AND BIOPRINTING, THE NEXT FRONTIER. As we explained, 3-D printing technology creates solid three-dimensional objects individually from a program loaded onto a computer. Layer after layer of material is deposited, building up the object being "printed." Some experts predict that 3-D printing will grow into a $3 billion industry by 2018.

*Nanoprinting* involves printing at the molecular scale to assemble larger molecules that constitute useful compounds as well as nanoscale machines; they have already demonstrated the ability to make simple drugs, like ibuprofen. *Bioprinting* involves printing with cells and growth factors to create 3-D tissues and organs. The even newer discipline of **bio-nanoprinting** merges these two technologies


***Famed geneticist Craig Venter, first laid out the idea of digitizing, transmitting, and printing "the information of life" at a 2012 conference sponsored by* Wired *magazine. Venter founded Celera Genomics and the Institute for Genomic Research. He is best known for creating the first living cell with a synthetic genome in 2010.***

to create both new living organisms and new biological molecules. The bio-nanoprinting process primarily involves writing proteins, as well as RNA and DNA using an alphabet of amino acids.

Leading the way into this bold new world of research is famed geneticist Craig Venter, who founded Celera Genomics and the Institute for Genomic Research. Venter is best known for being one of the first scientists to sequence the human genome in 2000, and for creating the first cell with a synthetic genome in 2010. While bio-nanoprinting sounds like science fiction, Venter's track record suggests that it is entirely within the realm of possibility.

At the *Wired* Health Conference in November 2012, Venter announced, "We found a way we can move proteins, viruses, and single human cells at the speed of light. We can digitize biology, send it at the speed of light and reconfigure the biology at the other end."[1]

What this means is that scientists will one day be able to *send a vaccine by e-mail.* In a world that is constantly at risk of a pandemic, it is critical to distribute a vaccine as soon as an outbreak occurs. But precious weeks and even months can be lost as researchers formulate the vaccine, a drug company manufactures it, and distributors disperse it to pharmacies around the world. During that time, the virus invariably spreads, rapidly increasing the number of people who are infected and making it exponentially more difficult and expensive to stop the outbreak.

With bio-nanoprinting, the researchers would simply send out an e-mail to doctors in any location where the virus poses a threat. Venter has figured out how to convert bio-molecules into digital code that can be read by "biological printers" in doctors' offices and medical clinics. The printers would simply print out the vaccine by creating the molecule one tiny bit at a time, and then doctors and nurses would inject it into the local population. Rather than sequentially printing millions of copies of the molecule for each patient, it's more likely that it would be spliced into a harmless bacterium that could create billions of copies in a few hours.

If it succeeds, bio-nanoprinting will create a new paradigm for global healthcare, in which science will be able to respond quickly to outbreaks of contagious diseases, and people around the world will receive access to new drugs as soon as they are proven to be safe and effective.

Based on this trend, we offer the following forecasts:

**First, bio-nanoprinting will act as a powerful defense and effective deterrent against bio-terrorism.** As explained in previous issues, advances in bio-technologies are making it easier for terrorists to create biological weapons and that creates new counter-terrorism challenges. Consider the facts: After the anthrax scare in late 2001, the U.S. government purchased 10 million doses of anthrax vaccine for the "Strategic National Stockpile." In the event of an anthrax attack, the government would have to distribute it to the location of the attack. This would only take days. But what if terrorists used a new or unexpected pathogen? Combining state-of-the-art sequencing technology and our growing genomic databases, scientists would be able to quickly identify the pathogen and formulate a vaccine. Then, with the aid of bio-nanoprinting, the vaccine could be e-mailed to strategic locations around the world where it could be assembled and administered. As with the Cold War doctrine of Mutually Assured Destruction, the knowledge that their targets had this defensive capability would make terrorists hesitant to pursue biological weapons capabilities.

**Second, in addition to saving time when a vaccine is urgently needed, such a system would save hundreds of millions of dollars in the event that the vaccine is *never* needed.** According to the Department of Homeland Security, every year the government throws away up to 2 million doses of expired anthrax vaccine, costing $48 million annually.[2] If the vaccine were printed on an "as-needed basis," the waste could be eliminated.

**Third, by 2030, bio-nanoprinting combined with low-cost genomics will make personalized medicine surprisingly cost-effective.** Historically, pharmaceutical companies have been forced to focus on "blockbuster" drugs so that development costs could be spread over millions of patients, each paying a high price. However, bio-informatics will soon enable them to identify therapies for rare diseases in small populations, while bio-nanoprinting will make tiny batch-sizes cost-effective. Physicians and nurse-practitioners will simply select the drug from a menu, and the bio-printer will produce pills or injections on demand.

**Fourth, bio-nanoprinting will become commercially significant only if mechanisms are put in place to minimize problems.** Small-scale bio-nanoprinting in remote locations — like doctor's offices, pharmacies, and hospitals — will have to address issues with data-security, quality-control, and FDA approval. Rigorous data encryption and verification processes will be required to ensure that files are not compromised. More importantly, bio-nanoprinting hardware and software will have to be routinely recertified to ensure that the molecules produced match the molecules specified. Small batches of drugs for rare diseases would not be amenable to the large-scale clinical trials typically required today and new regulatory standards will have to be put in place to accommodate them.

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## January 2013 Trend #5 Resource List:


1. *For more information about Craig Venter's bio-printing presentation, visit the Wired Health Conference website at:*
http://www.wired.com/wiredscience/2012/10/printable-life-forms/

2. *Fierce Homeland Security*, April 18, 2012, "Up to $48M of Expired Anthrax Vaccine Thrown Out Annually, Says DHS Official," by David Perera. © Copyright 2012 by FierceMarkets. All rights reserved.
http://www.fiercehomelandsecurity.com/story/48m-expired-anthrax-vaccine-thrown-out-annually-says-dhs-official/2012-04-18


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