Turning DNA into a hard drive

June 1 2012, By Eryn Brown

Silicon-based computers are fine for typing term papers and surfing the Web, but scientists want to make devices that can work on a far smaller scale, recording data within individual cells. One way to do that is to create a microscopic hard drive out of DNA, the molecule that already stores the genetic blueprints of all living things.

Stanford University bioengineer Drew Endy is a pioneer in the field of synthetic biology, which aims to turn the basic building blocks of nature into tools for designing living machines. Last week, members of his lab reported in *Proceedings of the National Academies of Sciences* that they had figured out a way to turn DNA into a rewriteable data storage device that can operate within a cell. He spoke with the Los Angeles Times about the research.

Q: What is synthetic biology?

A: Synthetic biology is basically a celebration of an engineer's inclination to want to make things using biology. Humans often learn by taking things apart. But an equally powerful way to learn is putting things back together. In synthetic biology, we can begin to put natural biological systems back together at the molecular level to test the understanding of genetics and biology we've accrued over the last 70 years.

Q: So you want to build things using biology - including, in this case, a way to use DNA to store data?

Yes. We wanted to scope out an area where there are grand challenges in bioengineering, and genetically-encoded data storage - meaning storing information inside living organisms - fit the bill.

Q: Why would this be useful?

A: Say I wanted to put a genetically-encoded counter to record cell divisions within every cell of my liver. A USB memory stick simply isn't going to fit in there. And even if I could miniaturize such a device with a future silicon-based manufacturing platform, it would be incredibly difficult to connect up to the biochemistry I'm going to want to record information about.

Q: How does your data storage system work?

A: We engineered a little sequence of DNA and inserted it onto a chromosome in an E. coli bacterium. Then we targeted this DNA with enzymes. Under one set of conditions, one of the enzymes cuts the DNA out from the genome, turns it and reinserts it back into the DNA. It would be as if you took a word in a sentence of text, flipped it upside down and backwards, and pasted it back into the sentence. It would look kind of funny.

Under a different set of conditions, a different set of enzymes finds that backwards DNA, cuts it out, flips it back to the normal orientation and glues the chromosome back together.

We encode a binary digit, or bit, within the DNA by mapping a "0" onto the normal orientation of the DNA and a "1" onto the flipped orientation of the DNA. DNA can only exist in one of two orientations, so it gives us a very nice way to store binary digits.

Q: The key development here was that you were able to flip your DNA switch back and forth, right?

A: Yes, that hadn't been done before. We thought it would be pretty easy, but it took us three years.

The enzyme that flips from state 0 to state 1 is called the integrase. The enzymes that flip it back are integrase and a controlling protein that modifies its behavior called excisionase. Balancing just the right amounts of the two enzymes in the cells took us 750 attempts.

Q: How might people use a technology like this?

A: I don't know. What we're working on are ideas to turn into tools that would make it possible to design, build and test things faster, more times or more smartly.

By analogy, the way we got from a room filled by one computer in 1952 to the "cloud" as it exists today was because of investments in tools. We got a lot better at silicon wafer manufacturing. We automated computer design so that human beings didn't have to do it manually. Somebody invested in some programming languages along the way. C++ didn't get discovered under a rock and Java wasn't grown on a tree. You have to work on tools.

Q: But certainly there are ideas for end uses out there.

A: Sure. My dreams for synthetic biology would include using tools we build to reinvent manufacturing, so that everything now sourced from fossil fuels could be manufactured on a sustainable basis. We could have a much richer partnership with nature. That's quite a big task.

People could use DNA data storage to control processes in sewage treatment plants. If there's a storm and a whole bunch of weird, oil-based runoff from the streets comes into the sewage treatment plant, the system could adapt automatically to better process those oils. You could use biobits in medicine, too. For example, if you wanted to target a tumor inside the body, you might need an engineered immune cell to replicate within the patient - but you wouldn't want it to replicate too many times, otherwise you'd trigger an autoimmune response.

I'm certain I don't know all the applications.

Q: What's next for your data storage module?

A: We're trying to scale this up. We want to get from one bit to a byte, which is eight bits. These systems don't need to be very big. If I had eight bits I could count up to 256, and I could start to study the development of an organism from a fertilized egg to a differentiated adult.

Another new dimension in the research is demonstrating that it will be possible to make this work in many organisms. We will support others who are working on that.

What we're likely to end up with will not look like classical electronics. Biology is beginning to teach us how to be a little bit more sophisticated in our engineering designs, which is a lot of fun.

Citation: Turning DNA into a hard drive (2012, June 1) retrieved 9 May 2024 from https://phys.org/news/2012-06-dna-hard.html

provided for information purposes only.