00:01

You're sitting in the doctor's office waiting for test results. She comes in and says, "You have Parkinson's disease." Your heart sinks, and you think about everything that will go wrong: you'll be unable to walk, unable to feed yourself, your hands trembling, drooling, unable to swallow. But before you say anything, she says, "Not to worry, we'll put in an order for your cells today." You come back a week later, and a surgeon transplants brand new neurons into your brain. You just received an on-demand functional cure for Parkinson's, made from your cells.

00:49

It sounds like science fiction, but in the future, we will all have the option of having our stem cells banked ahead of time so that any time you need new neurons, new muscle cells, new skin cells, they'd be generated from this bank. And because they're 100 percent your cells, your immune system is extremely unlikely to reject or attack those cells. In fact, the body has no idea that these cells were actually made in a cell factory. All of this is possible because of a breakthrough at the intersection of biology, laser physics and machine learning.

01:30

We'll start with biology. The human body is an absolute miracle. Trillions of cells are working in synchronicity to pump blood, secrete dopamine and let me see and speak to you right now. But as we age, our cells age, too. That's why our skin starts to sag, our cartilage wears away, and your five-mile run might turn into a 20-minute walk. Yes, we're all getting older. Our bodies are ticking time bombs. But stem cells could offer a solution, because one stem cell can become almost any cell in your body.

02:12

My grandma passed away due to diabetes in 2012. If the technology were available at the time, we could have used her stem cells to generate new pancreatic cells, and it could have cured her.

02:26

Now, unfortunately, stem cells are notoriously difficult to engineer. One fundamental problem relates to how they're made, which involves taking a patient's blood cells and adding chemicals to those blood cells to turn them into stem cells. Now, during this chemical process, you never end up with a perfect set of stem cells. In fact, you get a very messy plate of cells going in different directions -- towards the eye, brain, liver -- and every random cell must be removed.

02:58

Until recently, the main way to remove cells was by hand. I remember the first time I visited the Harvard Stem Cell Institute. I watched a highly skilled scientist sitting at a bench looking at stem cells, evaluating them one at a time and removing the unwanted cells by hand. It's a slow, tedious and artisanal process, which is why generating a personalized stem cell bank today costs about one million dollars.

03:31

Now, using a donor's stem cells is much cheaper, but your immune system will likely attack or reject those cells unless you take immunosuppressants, which, unfortunately, is not an option for a lot of people, especially the elderly. To avoid this problem, some scientists are banking stem cells from individuals with the most common genetic backgrounds. Here in the US, let's say we made a cell bank with 100 of the most common cell lines. It could work for about 75 percent of Caucasians, 50 percent of African Americans. But it gets harder. My cofounder is Filipina-Mexican, and it's unclear if she would be ever covered by a bank. And regardless, if you could choose between using a stranger's cells versus your own, wouldn't you choose your own?

04:31

Personalized stem cells are our opportunity to make medicines that truly work for me, for you and everyone. And in order to make this process of stem cell production affordable and scalable, we have to automate it. Different people are taking different approaches to doing that, and I decided to use physics. Since childhood, I've been a die-hard physics fan, gazing at the stars, daydreaming about space travel. Thanks, Mom, for not thinking I was weird! My family moved around a lot, from Saudi Arabia to Germany to Sri Lanka to Bangladesh, and each time, I had to learn new languages and cultures. Eventually, I fell in love with physics because it was a universal language that I didn't have to relearn every time.

05:23

When I started my PhD, I joined a laser physics lab, because lasers are the coolest. But I also decided to dabble in biology. I started using lasers to engineer human cells, and when I talked to biologists about it, they were amazed. Here's why: scientists are always looking for ways to make biology more precise. Sometimes cell culture can feel a lot like cooking: take some chemicals, put it in a pot, stir it, heat it, see what happens, try it all over again. In contrast, lasers are so precise, you can target one cell in millions at precise intervals -- every second, every minute, every hour -- you name it. I realized that instead of doing this tedious process of stem cell culture by hand, we could use lasers to remove the unwanted cells. And to automate the entire process, we decided to use machine learning to identify those unwanted cells and zap them. Algorithms today are great at finding useful information and images, making this a perfect use case for machine learning.

06:34

Here's how it works: Take some blood cells, put it in a cassette. Add chemicals to those blood cells to turn them into stem cells like always. Now, instead of having a human look for those unwanted cells and remove them by hand, the machine identifies the unwanted cells and zaps them with a laser. As you can see, this entire process happens by machine. The computer decides when and how often to print the cells and uses a fully automated system to run the process. After repeated pruning, you end up with a perfect culture of your stem cells, ready to be banked and used at any time. In the future, we're going to have stem cell farms with stacks and stacks of hundreds and then eventually millions of cassettes, each cassette a personalized bank for one human. Nurses will take a sample of your cord blood right at birth and ship it off for cultivation, so that for the rest of your life, your stem cells are on file, banked, ready to go, should any medical need arise. Let's say you develop heart disease. Your doctor can order up new heart cells. Hair loss. They can order up new hair.

07:50

The most immediate application of this technology is for implants. Dr. Kapil Bharti's research at the National Eye Institute has informed a breakthrough clinical trial for a stem cell derived therapy for blindness. As the process becomes cheaper, scientists can run larger and larger clinical trials at scale to develop new treatments that don't exist today, because what costs one million dollars today will soon be less than 50,000, and then even cheaper with time.

08:23

Now, it gets even more interesting than that. And perhaps you have longevity in mind. That is certainly a possibility. In the future, we might use these exact same stem cell banks to generate entire new organs, new tissues, new skin ... New bone, teeth, anyone? This technology also has the potential to revolutionize personalized pharmaceuticals. Today, taking medicine is, to some degree, trial and error. You don't really know if the drug is going to work for you until you put it in your body. But what if we had a miniature human replica of you with your cells -- eye cells, brain cells, heart cells, muscle cells, blood cells -- on a chip? A miniature human replica of you. We could take the drugs, test them on the cells in the lab first to see how it works. If it works, fantastic. Go ahead and take the drug. If it doesn't, pharmacists can order up custom drugs just for you. This has been the hope and dream of scientists for decades.

09:41

With this technology, we can finally realize the true potential of stem cells: on-demand functional cures made from your cells. Cures that your body won't reject. Cures that truly work for everyone. The future of regenerative medicine is 100 percent personalized, and it's a lot closer than you think.

10:12

Thank you.

10:14

(Applause)