Walter Isaacson Interviews MIT President Emerita Susan Hockfield on Overcoming the COVID-19 “Diagnostics Deficit” and How Convergence of Biology and Technology Will Drive 21st Century Innovation

Hockfield speaks with the author and Tulane University Professor of History for the latest CERAWeek Conversations – available at www.ceraweek.com/conversations

WASHINGTON, D.C. (July 7, 2020) – Massachusetts Institute of Technology President Emerita Susan Hockfield says that the “diagnostics deficit”—the lack of sufficiently accurate, rapid and cheap diagnostics—continues to “haunt” her in the response to COVID-19 and why bioengineering will be the “technology story of the 21st century” in the latest edition of CERAWeek Conversations by IHS Markit (NYSE: INFO).

In a conversation with award-winning author and Tulane University Professor of History Walter Isaacson, Hockfield talks about the inspiration for her new book, The Age of Living Machines; the potential for “nature-based” innovations in energy such as organic batteries and using microorganisms to capture carbon and break down plastics; marshalling innovation to meet the challenges of global population growth and the potential for a revival in U.S. manufacturing.

Dr. Hockfield is author of the new book The Living Machine: How Biology will Build the Next Technology Revolution. A neurobiologist known for her work on proteins and the brain, she is currently professor of neuroscience at MIT. Prior to becoming president of MIT, she was provost at Yale University.

Walter Isaacson is author of many best-selling books, including Steve Jobs, Leonardo DaVinci and Benjamin Franklin. At Tulane, he teaches the history of technology and is a
regular interviewer on PBS and CNN. His former positions include president of the Aspen Institute and editor of *Time* Magazine.

The complete video is available at: [www.ceraweek.com/conversations](http://www.ceraweek.com/conversations)

**Selected excerpts:**

**Interview Recorded Friday, June 26, 2020**

*(Edited slightly for brevity only)*

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- **On the origins of her thesis that biology and engineering will lead 21st century innovations:**

  “I discovered this convergence of biology with engineering as a major theme almost as soon as I was appointed as MIT’s president. I had a few months to get up to speed and I took those months to talk to everyone I possibly could to learn what I could about MIT. I had a pivotal conversation with the then-dean of engineering Tom Magnanti. He told me that of the almost 400 faculty members in the school of engineering, one-third of them were using biological parts in their work.

  “I was well aware of biomedical engineering, so I offered that as my understanding. He shook his head and said, ‘Well that’s only the smallest part of it.’ From then on, I just discovered so many new technologies emerging from the convergence of biology with engineering and the hard sciences. It’s an exciting story and I think it is going to be the technology story of the 21st century.”

- **On potential breakthroughs in medical treatment and diagnostics:**

  “The thing that continues to haunt me about our response to the coronavirus is what I call a diagnostics deficit. This nation has not turned its mind toward the importance of diagnostics. For the coronavirus we are seeing it writ-large even today. We don’t have sufficiently accurate, sufficiently rapid, sufficiently cheap diagnostics. The countries that have managed to control the coronavirus are countries that have been able to track and trace. To track you need to diagnose at a level that we aren’t even beginning to approach here in the United States. One of the technologies that I profile is a new way to diagnose disease.

  “This whole business of diagnostics, you don’t need it just in a pandemic. We spend 18% of GDP, roughly, on healthcare. While we have some breathtaking
new approaches to treat disease, I can use cancer as an example, truth be told, we are diagnosing cancer really late in the game. It’s much easier if you can diagnose cancer much earlier – it would be a lot easier to control it. But you need a diagnostic with greater sensitivity.

“[Another] acceleration of transformations that has happened that will partner with these kinds of tests is video medicine, teleconferencing. I’ve watched my colleagues in the medical sphere here in Boston, some of the best academic medical centers in the country, struggling to figure out how to do telemedicine. Guess what – the coronavirus made it happen.

“While we always like to imagine that there is a lone inventor, truth be told, that lone inventor doesn’t have the impact that she or he would have unless they connect to a community that helps bring a great idea into being. One of the things that has pleased me enormously is in the face of this pandemic across the Boston region, people have come together to find these solutions in ways that I had only dreamed of.”

• On the “parts lists” – the building blocks – for the 20th century digital revolution and 21st century bioengineering revolution:

“Much as I love all of my computer devices, I hadn’t really paused to think about where it came from. I realized that what enabled the electronics and the information, and the computer industries was the convergence of physics with engineering. The ‘parts list’ to physics really wasn’t known until 1900. [J.J.] Thomson discovered the electron in 1897 and the components of the atom were resolved. Engineers love a parts list and so they picked up those parts and turned them into the electronic gadgets that we have so enjoyed. The electronics, computer, and information industries, in my view, have been the most transformational technologies and industries of the 21st century.

“Biology didn’t have a parts list in the first half of the 20th Century. But it was only with the advent of molecular biology and genomics that we really had a parts list of biology that engineers were picking up to turn into technologies that really sound like science fiction, but they’re not. It’s an understanding that is not general yet, but I think it’s an exciting promise for solving the great challenges that are with us in the 21st Century.

“DNA, RNA, and I throw proteins in their too, because the DNA and RNA by themselves rarely manifest function. The DNA and the RNA that produce these fantastic little machines called proteins really represent a parts list that allow engineers to build incredible new kinds of technology with the kind of resolution –
biological parts are very, very small and it allows engineers to build from very small components really extraordinary new kinds of technologies.”

- **Tangible examples of biology-based engineering:**

  “One of my favorites is for water. We have been purifying water for thousands of years. We have been distilling dirty water to provide clean water for thousands of years or filtering it through sand or now through complex chemically built filters. And yet today we don’t have anywhere near enough clean water to meet the world’s needs. It’s a hard problem, but our cells, the cells in every organism on earth, have figured out how to purify water.

  “It ends up that water control in cells is mediated by a protein – a very, very small channel that regulates the flow of water into and out of a cell. It was discovered by a hematologist named Peter Agre at Johns Hopkins University and he did an incredible set of studies on this protein that he named aquaporin – or ‘water pore.’ And every organism uses this water pore.

  “As he was doing the basic science around this there was a biophysicist entrepreneur who was following the work and he said to himself: if our cells use this magnificent protein to purify water, could we use that protein to purify water for our use? He said: I could bust my brain trying to invent a new way to purify water. But why don’t I just use nature’s genius to do it for us?”

- **Nature-based models for energy innovation:**

  “Obviously we face an incredible energy challenge. Our energy use right now is unsustainable, and we’ve got to get to a better energy future, a more sustainable energy future. The rate-limiting technology for intermittent energy sources is actually energy storage. We have gotten better and better at batteries but still, state-of-the-art lithium ion batteries aren’t going to be the sustainable solution that we need to really scale up energy to the level we need.

  “A colleague of mine at MIT was fascinated in biological organisms and how they do their work without contaminating their world; and she thought if the abalone can build its shell and then have that shell disintegrate when the abalone dies without contaminating the ocean in which it lives, why can’t we?

  “She has persuaded viruses, benign lab strings of viruses, to assemble the components of batteries. The batteries that her viruses build are built at room temperature without any toxic byproducts. And the batteries have the same charge density – they can hold the same amount of electricity as a state-of-the-art lithium ion battery – and can cycle through charge and discharge cycles the
same as state-of-the art lithium ion batteries. But if we can use nature to build our batteries, we would be far better off. And this could get us to a much better energy future."

- Future opportunities and ongoing challenges for biology-based revolutions in energy:

“The idea of using biology in the energy domain holds enormous promise. The most obvious one is biofuels and that has proved to be much harder than we ever imagined. Part of it is because nature is very conservative. Nature likes doing things the way she does them. You can persuade some bacterium to make a biofuel that it doesn’t normally make. But when given a chance to run free it reverts back to its normal form. Biofuels are still promising but they’re out there a bit.

“One of the approaches that is very promising is that we think of the fossil fuel problem in terms of what we put into our cars and trucks and airplanes. But there’s another really big problem in that fossil fuels are the feedstock for many of the materials that we enjoy today. There’s a lot of really important work on figuring out how to organically generate those feedstocks and not having to go back to oil and gas to actually produce the plastics that we need. On the other side of it we also need to be able to get rid of the plastics. That’s also a very promising direction where people are designing new ways to break down plastics, again using microorganisms that are all around us.

“I know of a number of projects on carbon capture. The kinetics of CO2 capture and conversion are pretty tricky. But people are making a lot of great progress using bio-organisms to do the hard work that has to be done at a very small scale. There’s a lot of promise. But like everything else, that promise takes a lot of work, takes a lot of financial support, and takes an innovation system that actually is set up to accelerate the hard tech, that is, making physical things change. That’s a tough problem.”

- On biological innovations addressing global crises:

“The Reverend Thomas Robert Malthus in 1798 wrote a treatise on the Principle of Population. He made this observation: when population grows faster than agricultural productivity you end up with war, and famine, and pestilence, and these external factors that reduce the population back down to a level that the resources can support. In 1798 he sounded the warning call: it was going to happen again.

“My thesis is that we are, right now, in another Malthusian dilemma. We’ve got somewhere in the neighborhood of 7.2-7.5 billion people in the planet. And the
best prognosticators tell us that we’re going to have close to 10 billion by around 2050. How are we going to meet the needs of 10 billion people without again falling into the Malthusian dilemma? My answer to that is: in the past when we’ve been smart and lucky, we’ve innovated our way out. I think we can do it again.

“My fear is that great bursts of technology progress are usually catalyzed by war. World War II is a shiny example of the kind of technology development that can happen over a very short period under the pressure of an existential threat. I hope that our next episode of technological innovation can be driven by not the threat of war, but the promise of peace. Because these existential threats today are not just theoretical threats, they are threats that will, in a Malthusian prediction, result in war, and pestilence, and famine if we don’t figure out how to innovate our way out of it.”

- **On the future of U.S. manufacturing:**

  “When we talk about reviving U.S. manufacturing people often think about going back to the manufacturing modalities of the past. And that’s not going to be a winning solution. The manufacturing modalities of the future is a place that the United States can and should play.

  “I co-chaired the Advanced Manufacturing Partnership with Andrew Liveris under President Obama; it recommended that we start up manufacturing hubs to get started to bring together the academy, industry, finance to figure out how to use our nation’s strengths to innovate a new manufacturing revolution. The things we’ve been talking about could well be deployed to the manufacturing revolution of the future that can be done in a very different way from the manufacturing of the past and once again is the promise for not just betterment of lives in the United States, but around the world.

  “There is a bill making steady progress, called the Endless Frontiers Act, that has two components. One component is setting up the National Science Foundation as the place with the responsibility to actually accelerate the science and the engineering, but also accelerate the translation into products for the marketplace. Along with that funding for the National Science Foundation for the projects themselves is funding for additional manufacturing hubs to drive these technologies as rapidly as possible into the manufacturing powers for the 21st century.”

  **About CERAWeek Conversations:**
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