Thoughts on the Technological Frontier Transforming the Life Sciences: Opportunities for Pennsylvania

Testimony to the Pennsylvania Senate Committee on Communications and Technology

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Introduction

Greetings, my name is Burak Ozdoganlar, and I am the Ver Planck Endowed Chair Professor of Mechanical Engineering with appointments in Biomedical Engineering and Materials Science and Engineering, as well as the Neuroscience Institute at Carnegie Mellon University. I am also the Associate Director of the Engineering Research Accelerator at CMU's College of Engineering. I have been a faculty member at Carnegie Mellon University for over 22 years. My research focuses on medical and biomedical device development, biofabrication, and micro- and nano-fabrication. I have also been the co-director of the Pennsylvania Infrastructure Technology Alliance (PITA), funded by the State of Pennsylvania through DCED, for more than 10 years. Over my 22-year career, my research and innovation efforts have resulted in more than 200 scientific publications, 25 issued patents and nonprovisional patent applications, and more than $75 million in research grants and contracts. I have also served on companies' technical advisory boards and helped launch biomedical commercialization efforts, including participation in a spin-off company.

Much of my career has been dedicated to harnessing advances in engineering, materials, and fabrication technologies at the micro- and nanoscale, with the aim of developing real-world, clinical applications that can have a transformative impact on medical care. More recently, we have progressively used machine learning and AI techniques to accelerate our advances. This includes improving how we design systems, interpret complex biological data, and evaluate performance. My remarks will focus on three areas:

First, I will draw upon research and innovation being developed at Carnegie Mellon to highlight the range and scale of impact developments in Artificial Intelligence hold for the future of the life sciences.

Second, I will highlight how converging innovations in bioengineering, advanced materials, and biofabrication, combined with AI and machine learning, are transforming patient care and the medical device industry. The applications shaped by this convergence hold opportunities for Pennsylvania's leadership in the life sciences.

Finally, having witnessed and benefited from the value and impact of Pennsylvania investments in innovation, I will offer some thoughts on potential strategies to ensure these transformations enhance the quality of life of Pennsylvanians and the vitality of our economy.

We are at a crucial turning point. The potential is evident. Already, AI applications are diagnosing bone fractures, detecting cancerous regions in mammograms, and interpreting brain scans with expert-level performance in some settings. AI is also accelerating drug development and providing tools to reduce the administrative burden on clinicians. My work and my colleagues' work also demonstrate that, combined with advances in materials and biofabrication approaches, breakthroughs in AI can revolutionize diagnosis and treatment through a new generation of medical devices. Deliberate innovation strategies will be needed to ensure that these breakthroughs are accessible to all communities and citizens.

Perspectives from Carnegie Mellon on the Impact of Accelerating Breakthroughs in AI on the Life Sciences

Research underway at Carnegie Mellon demonstrates the scale and scope of AI's potential to advance the life sciences and improve health care. Across these efforts, AI is being used to help researchers and clinicians better use complex data, design more effective experiments, and build tools that support patients and care teams.

One major focus at CMU is using AI to accelerate and enhance the research process. Carnegie Mellon has invested $50 million to create an academic automated science lab. The AI Science Foundry is being designed to support AI-enabled experimentation by connecting physical laboratory instruments with digital tools. In practical terms, the Foundry aims to help researchers plan experiments, run them more efficiently, and improve reproducibility.

At the cellular and molecular level, computational biology research is using machine learning to analyze large biological datasets, including genetic profiles of cancer cells, to improve understanding of how disease evolves and why some cancers resist treatment. Researchers are also developing tools to study genetic links to neurodegenerative diseases, such as Alzheimer's, and to identify specific DNA sequences that act as cellular switches. These approaches can enable more precise targeting in gene delivery and cell-based therapies.

Significant work is also underway on AI to support mental health. This includes tools that can improve the training of mental health professionals and approaches that may help monitor depression and related conditions more effectively.

CMU researchers are also applying AI to strengthen health care preparedness. Support from the Centers for Disease Control and the National Science Foundation is advancing university centers and initiatives that apply AI to improve health care delivery during disasters and to develop new tools for monitoring pandemics. These efforts benefit from collaboration with Commonwealth agencies.

Advances in AI and robotics are also helping improve procedures and interventions. Work in this area includes miniature surgical robots and handheld instruments that reduce the impact of hand tremor during microsurgery, supporting surgeons in improving precision. Machine learning applied to brain imaging is also contributing to progress in noninvasive neuromodulation research, and collaborations with the University of Pittsburgh are advancing noninvasive brain-computer interface capabilities to assist individuals with paralysis.

Applications of robotic capabilities are also enabling the creation of exoskeletons to restore and enhance mobility. On a larger system scale, advances in robotics and autonomous systems may one day create new pathways to providing emergency care. A CMU-Pitt research team is participating in a Department of Defense project to develop portable, autonomous systems that can assess and monitor injured individuals in remote locations where medical care is not immediately available. The potential to provide more rapid triage and support to individuals in rural communities could be one outcome of work in this area.

Finally, these innovations depend not only on algorithms but also on responsible implementation. As AI becomes more widely used in health settings, it will be important to ensure strong protections for privacy and security, careful validation before deployment, and ongoing monitoring to maintain safety and trust.

Opportunities at the Convergence of Major Streams of Innovation to Transform the Life Sciences

A defining feature of this moment is that we are seeing rapid breakthroughs across multiple disciplines that, together, have the potential to transform the life sciences. Alongside advances in artificial intelligence, there are major developments in advanced materials, nanotechnology, and nano-scale fabrication. This convergence is creating a new frontier for medical treatments, diagnostics, and medical devices.

One example is the evolution of a new generation of wearable technologies. At Carnegie Mellon, my colleagues and I are developing a new class of wearables made from soft polymers and hydrogels, combined with stretchable, flexible electronics, to enable more comfortable, continuous health monitoring. Some of these systems are designed to operate at very low power and, in some cases, may be able to draw small amounts of energy from the body. AI adds value by helping interpret continuous data streams, flagging early warning signs, and supporting timely decisions by patients and care teams.

A second critical area is the rapid progress in 3D bioprinting. Advances in bioreactors, bioinks, and printing technologies are bringing the field closer to the creation of more complex and functional tissues. While substantial work remains, the direction of progress suggests that bioprinted tissues and, eventually, whole-organ constructs may become more feasible and more affordable over time. A team at Carnegie Mellon and the Mayo Clinic, of which I am a member, is collaborating on an ARPA-Hsupported project to produce a bioprinted liver that remains viable and functional for transplantation.

One overarching area at the center of this convergence is bioelectric medicine, which involves the creation and application of bioelectronic devices and therapies to improve health. ***Carnegie Mellon is a leader in bioelectric medicine***, with faculty across multiple departments advancing high-impact applications. In the last year alone, this work has attracted more than $125 million in funding from the Advanced Research Projects Agency for Health (ARPA-H) and the DARPA BioTechnologies Office. I am leading one of these large projects and co-leading another. These initiatives are designed to move quickly from proof of concept toward practical deployment, with clear performance milestones and validation plans.

My own research focuses on three areas. The first involves developing engineered tissues that emulate key behaviors of human tissues. We build tissue-on-chip platforms that emulate the structure and function of real tissues and incorporate features such as vasculature, lymphatic pathways, and relevant cell types. These systems can support more effective studies of drug response, tissue function, and disease progression for applications such as cancer. For example, we can engineer a tumor model and study responses to various therapies, including immune-based treatments. Over time, this work may expand toward engineered tissues for regenerative medicine and, potentially, transplant-related applications.

The second area involves the development of biointegrated implantable systems for cell-based sensing and therapy. In an $42 million ARPA-H project that I lead, we are developing an implantable system that combines engineered cells with bioelectronics to measure biomarkers, such as hormone levels, and deliver the right therapeutic response when needed. The long-term goal is to improve disease management for chronic and hormonal diseases, such as diabetes, obesity, and thyroid disorders, and to reduce the burden of daily pills and trial-and-error dosing.

A third area is the development of new systems and devices for disease detection and treatment, with an emphasis on enabling earlier, less invasive, and easier-to-use testing in real-world settings. One example is our work on microneedle-based sampling and sensing. In this project, we use microneedle arrays to collect very small volumes of blood or interstitial fluid with minimal discomfort. We then pair that sampling interface with an integrated microfluidic chip that processes the sample and detects infection- or disease-related biomarkers. The broader goal is to move beyond single measurements and toward practical, near-patient systems that can support screening, monitoring, and timely clinical decision-making.

A second example is a $26.7 million ARPA-H project that I co-lead to develop a safe, affordable, homebased multi-cancer early-detection test using a simple urine sample. Many of the deadliest cancers are treatable when caught early, but they are often diagnosed late because early disease can be silent, and current screening tools are limited, expensive, or hard to access. Our goal is to change that by enabling detection of very early-stage cancers and, critically, providing a tissue-of-origin signal to help guide what follow-up test should come next. In other words, this is not only about flagging risk but also about guiding clinicians to the right next diagnostic step sooner, when earlier intervention can make the greatest difference. This approach could make high-quality early detection far more accessible by shifting screening from specialized settings to a practical, low-burden home test and by helping patients move more quickly to confirmatory evaluation when time matters most. The long-term impact would be a meaningful shift toward earlier diagnosis, when treatment options are broader, care can be less invasive, and outcomes are substantially better.

Across these areas, AI can play an important role. It can help design and optimize complex biological systems, interpret multi-parameter signals from sensors and tissue platforms, and support reliable performance as these technologies move from lab demonstrations toward real-world use.

Together, these converging advances create opportunities for Pennsylvania to lead in research, new company formation, and responsible deployment of next-generation health technologies, in partnership with our health systems, workforce programs, and industry base.

Thoughts on Opportunities for Pennsylvania to Continue to Benefit from Leadership at the Frontier of the Life Sciences

These research initiatives demonstrate the potential for a new generation of innovation at the intersection of critical advances that can fundamentally transform the life sciences. These transformations can bring new, cost-effective care, create high-skill jobs, and improve access to health technologies for communities across Pennsylvania, including rural regions.

Realizing this potential depends in part on sustaining strong federal research investment across agencies such as NIH, ARPA-H, DARPA-BTO, the Department of Defense health programs, and the National Science Foundation. Pennsylvania's leadership in the life sciences begins with these essential federal investments, and it can be expanded by supporting early research and development that positions Pennsylvania teams to win major grants, contracts, and partnerships.

In this new era, access to advanced computing is also a fundamental building block. A Commonwealth computing strategy will be important for the future, including secure computing environments for sensitive health data, shared access for universities and start-ups, and workforce development for data and AI skills. Home to one of the original national supercomputing centers, the Pittsburgh Supercomputing Center provides a strong foundation.

The following are thoughts drawn from my experience as a researcher and innovator on two additional areas for potential action.

Strengthen Collaboration Among the Pennsylvania Healthcare Industry and Academic Institutions. Collaboration across institutions and between institutions and industry is essential to advance both research and commercialization by leveraging AI and the interconnected technologies shaping the future of life sciences. Each of the ARPA-H projects I have mentioned includes researchers from multiple universities, health centers, and commercial partners to ensure the interdisciplinary capabilities this work demands and to support a rapid path to real-world deployment.

Carnegie Mellon benefits from a long history of deep collaboration in the life sciences with the University of Pittsburgh, including joint degree programs and joint centers. One of the leading life sciences start-ups, Abridge, is advancing AI tools to reduce the administrative burden on clinicians and improve documentation workflows. Similarly, joint research initiatives exist between CMU, the University of Pittsburgh, UPMC, and Highmark. Longstanding cross-state collaborations with Lehigh, Penn State, and Penn in several fields have also been critical. The Pittsburgh Life Sciences Alliance and Life Sciences PA provide networking and strategy development capabilities to enhance collaboration.

Clear opportunities exist to build upon this history of collaboration to launch more formal mechanisms to accelerate joint research and development initiatives. Such efforts could include:

- Joint tech-transfer agreements and shared accelerator capabilities to speed the formation of start-ups,
- Shared testbeds for evaluation and validation of AI-enabled health technologies, in partnership with health systems,

- Collaborative programs that connect university researchers and students with industry-defined projects focused on emerging healthcare technologies, building on successful models such as PITA and the Pennsylvania Manufacturing Innovation Partnership.

These collaborative efforts can also lead to the formation of additional spin-off companies in Pennsylvania, further expanding the Commonwealth's impact and leadership in biomedicine and AI. As these partnerships grow, they should also include clear expectations for privacy, cybersecurity, validation before deployment, and ongoing monitoring when AI tools are used in health settings.

Develop the Education and Workforce Strategies to Support Next Generation Life Sciences. A multilayered education and workforce strategy is needed to realize the full potential of this transformation. First, the training of researchers must recognize the imperative to work across disciplines to accelerate breakthroughs enabled by AI. The work I have described today depends on collaboration among engineers and engineering scientists, medical professionals, computer scientists, materials scientists, social scientists, business, and public policy specialists. In addition, it is critical to foster collaboration among life science researchers and specialists in privacy, security, and trustworthy AI.

At CMU, an environment has been created for these cross-disciplinary specialists to work side by side. In addition, the College of Engineering has added graduate programs in AI across its major engineering specializations, including mechanical, biomedical, and civil engineering. Future undergraduate and graduate training, as well as investments in lab and research infrastructure, will need to respond to these imperatives for vibrant education and collaboration programs.

Second, these advances will have significant impacts on the work of nurses, technicians, home health care, and public health professionals. Data and human-machine teaming skills will likely be increasingly important additions to the rich array of capabilities these workers bring to the service of patients. The development of automated AI labs is also likely to create entirely new technician roles. Creating close alignment and collaboration among research institutions and professional education and training programs, including community colleges and regional workforce partners, can help ensure that workers across all regions of the Commonwealth are prepared for these new opportunities.

Finally, this new era can energize STEM education. Entirely new careers in industry and health care are likely to emerge. Pennsylvania's extensive base of academic and industry leaders at the forefront of these advances creates the potential for partnerships to ensure that students in all regions of the Commonwealth can engage with this new world early in their education.

Conclusion

Thank you for convening this important hearing. As I noted in my opening, I have benefited from Commonwealth investments that have enhanced my research by providing opportunities to work closely with Pennsylvania's leading companies. This experience, and the potential I see in the work being done at Carnegie Mellon and across the state, leave me optimistic about Pennsylvania's ability to lead the next wave of health care innovation and improve the quality of life for our citizens.

In closing, I would emphasize three practical priorities for the Commonwealth:

- ***Strengthen collaboration mechanisms*** that connect universities, health systems, and industry to move promising AI-enabled health technologies from research to real-world use.
- ***Support secure computing and data infrastructure*** needed to develop, test, and deploy AI responsibly in health and biotechnology settings.
- ***Invest in workforce development*** so Pennsylvanians across regions are prepared for new roles created by AI and biotechnology, including technicians and health care professionals who will work alongside these tools.

As Pennsylvania pursues these opportunities, it will be important to include clear expectations for privacy, cybersecurity, validation before deployment, and ongoing monitoring when AI tools are used in health settings. Thank you for your leadership and the opportunity to provide testimony on this vital topic. I would be pleased to serve as a resource to the Committee as you continue this work.