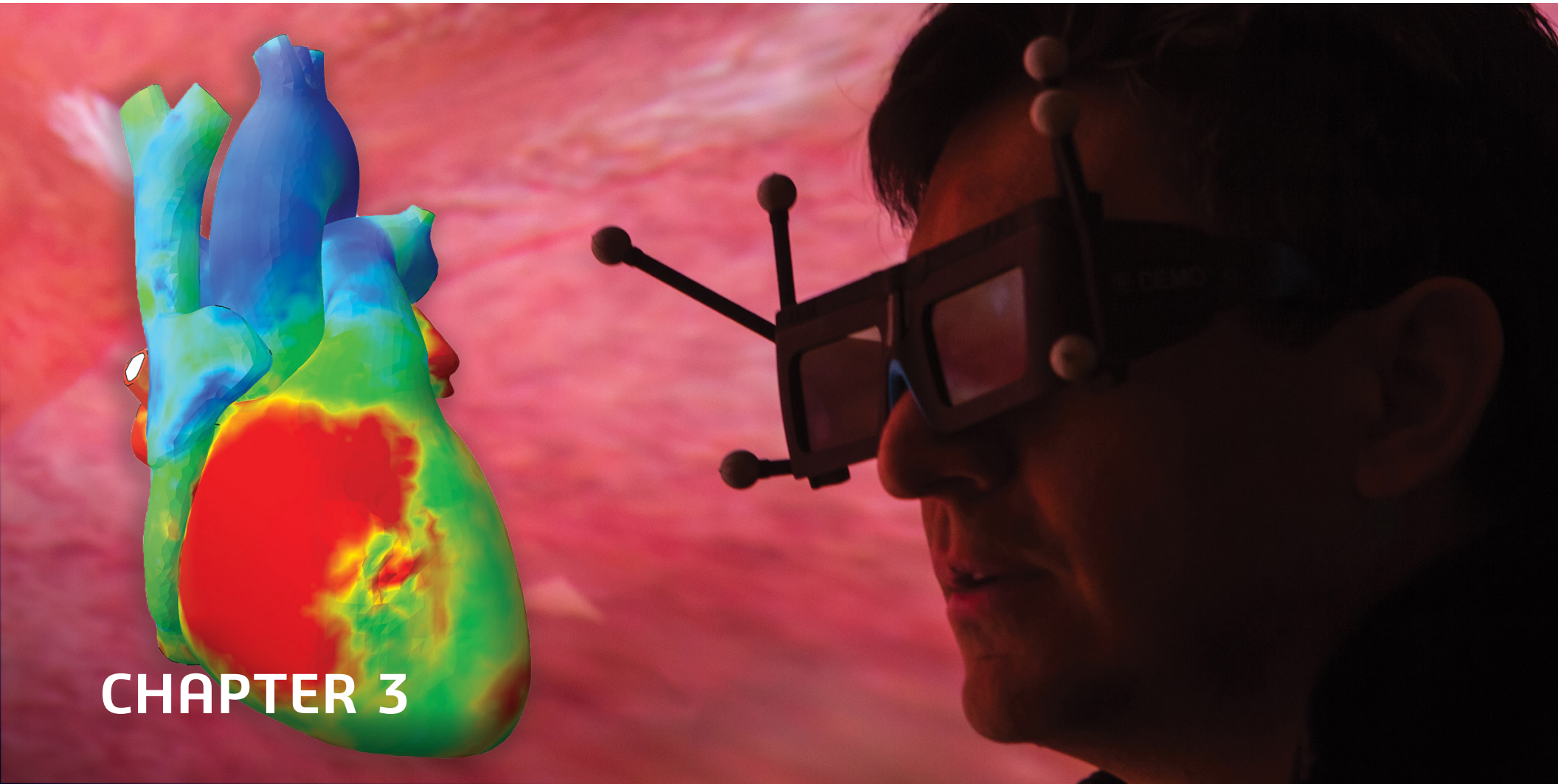
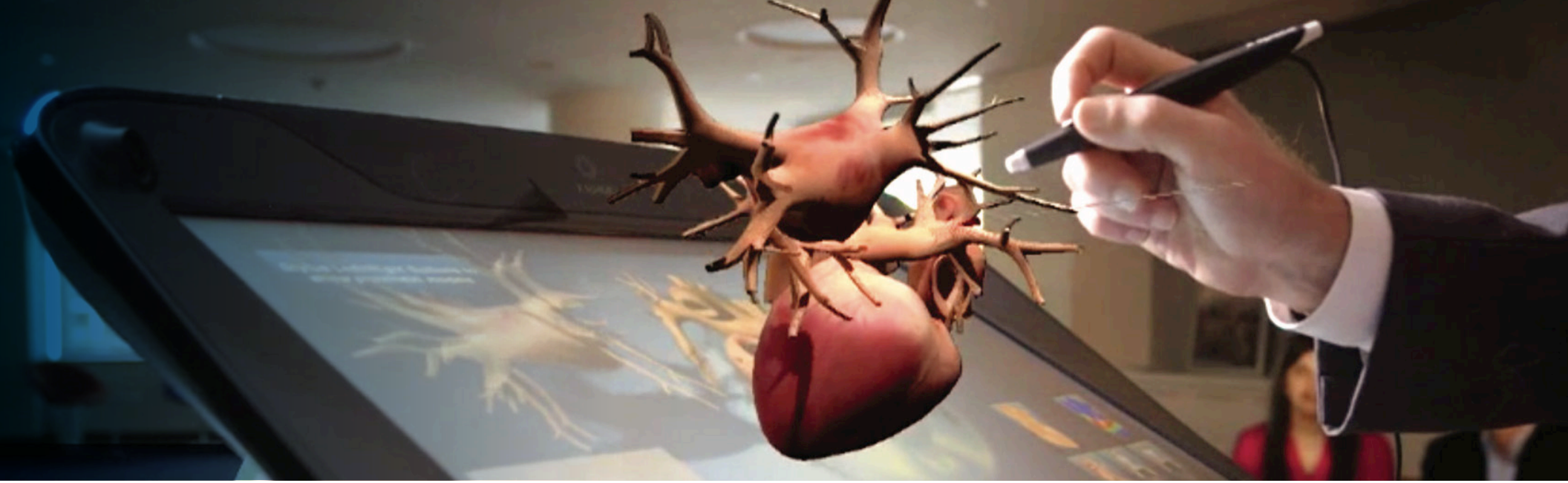
DASSAULT SYSTEMES

LEADING THROUGH LEARNING

HOW CLOSER WORKING RELATIONSHIPS BETWEEN SCIENTISTS, PRACTITIONERS AND DEVELOPERS RESULT IN MORE POWERFUL APPLICATIONS AND MORE EFFECTIVE TREATMENTS



CHAPTER 3



Even for seasoned physicians and scientists, it's hard not to marvel at the human heart. This amazing, incredibly complex organ is the cornerstone of human life — a self-regulating, always-running engine supplying the body and brain with vital oxygen and nutrients through a labyrinthine vascular network. Even before the moment of birth, its layers upon layers of specialized fibrous tissue seamlessly interoperate to deliver blood to the furthest reaches of the body, adapting flow and function automatically as necessary to compensate for changing physical circumstances.

That is, until it doesn't. The effects of a compromised, malfunctioning, or injured human heart are instantly reflected in a corresponding decline in the other bodily systems it supports; when sufficiently damaged, the inevitable consequence is death.

It is a catastrophic outcome for individual patients and their families, and an incredible cost for human society. Cardiovascular disease is the world's leading cause of death, and is responsible for more than 30 percent of annual deaths*. Additionally, some 40 percent of the world's population will ultimately suffer from some form of cardiovascular disease. In the United States, recent statistics show that treating cardiovascular disease costs approximately $555 billion annually**, a figure likely to rise to $1 trillion by 2035 according to a recent study by the American Heart Association.

IN THE US, CARDIOVASCULAR DISEASE TREATMENT CURRENTLY COSTS APPROXIMATELY

$555

BILLION ANNUALLY

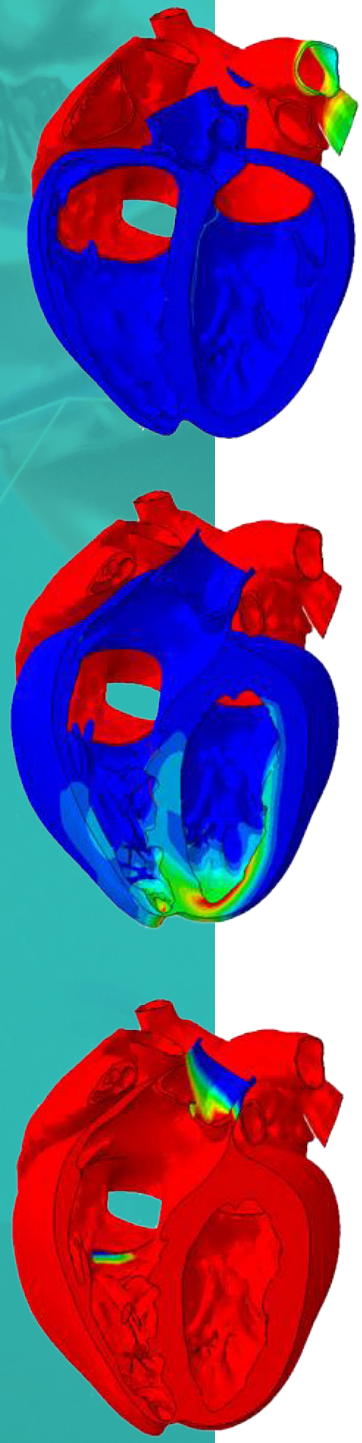
SOURCE: HTTPS://HEALTHMETRICS.HEART.ORG/WP-CONTENT/UPLOADS/2017/10/CARDIOVASCULAR-DISEASE-A-COSTLY-BURDEN.PDF

* SOURCE FOR PREVALENCE/DEATH STATISTICS: HTTP://WWW.WHO.INT/NEWS-ROOM/FACT-SHEETS/DETAIL/CARDIOVASCULAR-DISEASES-(CVDS)

**SOURCE: HTTPS://HEALTHMETRICS.HEART.ORG/WP-CONTENT/UPLOADS/2017/10/CARDIOVASCULAR-DISEASE-A-COSTLY-BURDEN.PDF

"We began with the drive to use digital technology to improve life as we knew it... "

– Dr. Steve Levine, head of Dassault Systèmes' (DS) Living Heart Project



It's clear that the need to develop more effective means of treating and preventing heart disease is both pressing and universal. While the medical sciences have achieved tremendous breakthroughs in knowledge and treatment, the pace of advancement has been constrained by our limited ability to look inside a functioning heart or subject it to experimentation, placing researchers and practitioners at a disadvantage.

The need to learn more about how the heart works and how its afflictions might be treated led Dassault Systèmes to launch the Living Heart initiative, an ambitious collaborative project aimed at developing a comprehensive digital functional model of the heart. Beginning in 2014, the company drew together researchers, clinicians, regulators, and industry representatives to share their information and expertise to advance this objective. Attracted by its stated mission to "advance development of safe and effective cardiovascular products and treatments by uniting engineering, scientific, and biomedical experts to deliver validated models and translate simulation technology into improved patient care," the initial twelve-member team set to work using Dassault Systèmes' 3DEXPERIENCE cloud-based shared development platform.

"We began with the drive to use digital technology to improve life as we knew it," says Dr. Steve Levine, head of Dassault Systèmes' Living Heart Project. "Could we simulate something as profound as the human heart? Could we understand the physics, the electromechanical behavior, and predict how devices would interact—to make them better, test them, and make them safer, and more reliable, before they're ever put into a human body?"

Building from an existing baseline data set, the team began to answer this question by refining the system's models for electrical conductivity, including the electrical behavior of human tissue. Team members contributed additional data drawn from their own areas of specialty, working collaboratively to ensure accuracy. The group then created the first iteration of the Living Heart—a dynamic 3D virtual model of a living human heart that could be viewed internally and externally from all angles, cross sections, and dimensions.

The project has since grown to include the contributions of 49 research partners, 35 corporate partners, and ten clinicians from around the world, and has secured the support of the Food and Drug Administration and the Medical Device Innovation Consortium. Through the contributors' combined knowledge and diligent efforts to refine the project's methodology and model, the current iteration of the Living Heart has become capable of accurately modeling virtually the full spectrum of heart functions—flows, volumes, mechanical functions, and electrical functions.

With these capabilities, researchers and device developers gain the ability to introduce models of specific devices or treatments, simulate their performance in conditions nearly identical to "real life" circumstances, and gauge their efficacy and impact with a high degree of certainty. This permits a level of experimentation and testing impossible to achieve using live animal studies, and which typically cannot be undertaken at all using human subjects. In addition, since modeling and simulation do not consume the same time, expense, or physical resources as animal or cadaver studies, tests can be quickly conducted and iteratively repeated, enabling devices and methodologies to be continually refined.

More significantly, the Living Heart has transitioned from the generic to the personal. CT, MRI, EKG, and other data from individual patients can be imported into the system, analyzed, and rendered as a functioning model of the patient's specific heart—including any abnormalities, defects, diseases, or

The Living Heart enables researchers to simulate the performance of devices and treatments nearly identical to "real life" — including testing that's impossible to conduct through animal or human studies.

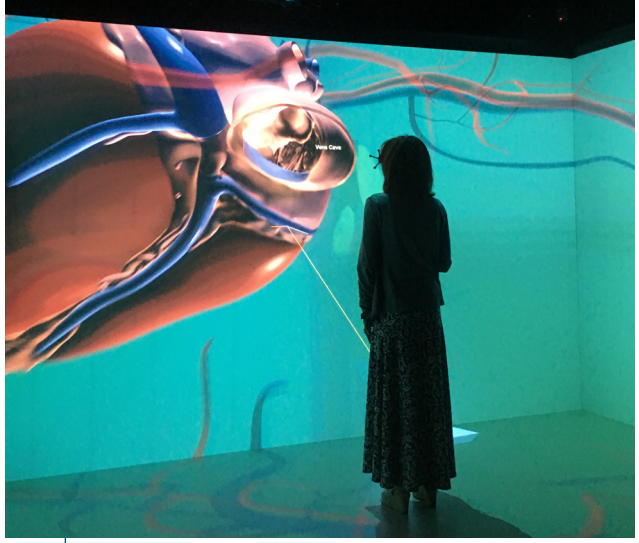
dysfunctions. As a result of this development, clinicians and surgeons gain additional vital insights into a patient's specific circumstances and needs; testing and simulation can forecast outcomes of specific surgical procedures, drug treatments, or device implantations; surgeries and procedures can be practiced beforehand, optimizing their efficiency and efficacy; and, through the gaining of greater knowledge of the individual heart's specific function and physiognomy, unnecessary risks can be averted. All of this adds up to the likelihood of improved patient experiences and treatment outcomes.

Beyond development of the world's most advanced, openly accessible human heart model, the Living Heart Project achieved another notable milestone: Developing a template and framework for 3D experience-based collaboration, knowledge sharing, and scientific advancement that could be applied to other Life Sciences specialties. The project's success in developing a viable model of one of the body's most complex, delicate organs served as validation of the technology and the methodology for developing equally powerful models for other organs and systems, as well as for testing treatments and devices related to them.

Pursuit of the Living Heart Project provided Dassault Systèmes developers with a rare opportunity to work with a global, cross-disciplinary team using their products, and to gain vital, immediate feedback. The team was able to see firsthand how a wide range of professionals from multiple disciplines used the 3DEXPERIENCE technology, and to use this knowledge as the basis for future refinements as well as possible specialized functions keyed to specific interest and practice areas.

"As society seeks personalized health care while ensuring optimum industrial security, the time has come for Life Sciences to, at last, leverage the tremendous power of the virtual world. Digital environments are pushing the boundaries of possibility to transform research, science, the pharmaceutical industry and medicine in general," says Bernard Charlès, Chief Executive Officer of Dassault Systèmes. "Innovation is about imagining worlds that don't yet exist—worlds that await us in the future. Digital is about making these new worlds possible."

The practical ramifications of the Living Heart project are only beginning to be felt as scientific papers are published, new treatments are developed, and new products are refined leveraging the technology. As they prove their worth through peer review and in practice, the Living Heart project and the collaborative methodology and simulation model supporting it stand to radically transform medical research and practice, including the process of gaining regulatory approval.



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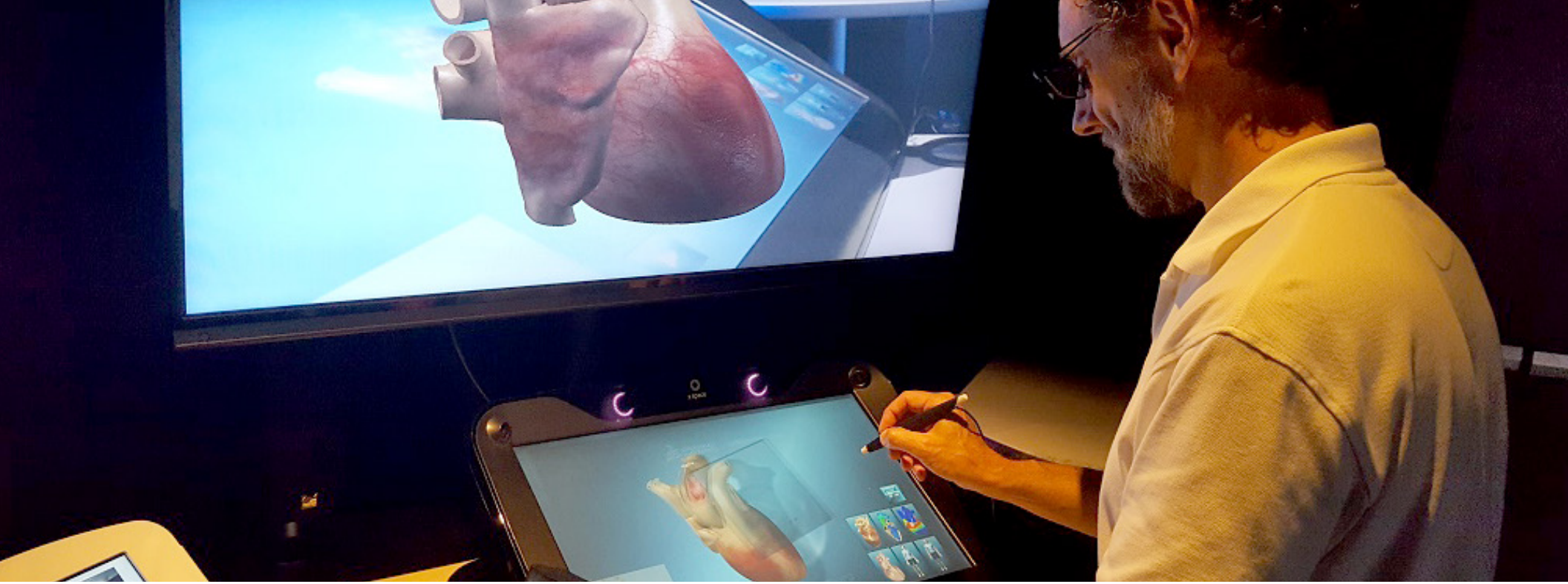

In response to the success of the Living Heart and other advanced simulation initiatives, regulators are growing increasingly responsive to computational modeling and simulation as a component of medical device development and testing processes. The FDA recently launched a new Medical Device Development Tools program, which includes a category for nonclinical assessment models incorporating computer modeling and simulation. "The Living Heart Project opened a Pandora's box on this whole new paradigm of modeling and simulation within medical devices and working in collaboration with the FDA," says Arieh Halpern, Life Sciences Director for Dassault Systèmes. "It's a whole new era that the FDA and the industry see as extremely valuable in being able to bring newer products to the market safer and faster."

By combining the knowledge and expertise of experts from around the world within a sophisticated collaborative environment and leveraging that knowledge to present a dynamic, accurate model of individual heart structures and functions, the Living Heart Project creates a new avenue of hope for millions of cardiac patients. Perhaps more importantly, it blazes a new trail for future innovation. The collaborative, technology-driven methodology driving the project serves as a possible model for unlocking the secrets of other organs, ailments, and treatments - with the potential to transform medicine and impact millions of lives.