HealthQuake SUMMIT

The Convergence of Medicine and Technology

REPORT 2017

DETROIT

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Detroit International Research & Education Foundation
c/o Department of Surgery
3990 John R Street
Detroit, Michigan 48201
United States of America

Tel.: +1 (313) 405-6054
Email: dellis@diref.org
www.diref.org

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Foreword

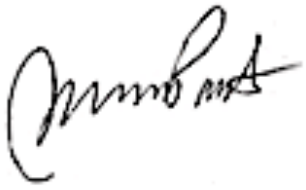
I was proud to welcome our first HealthQuake Summit delegates to a resurgent, reborn Detroit; a city with great and original beauty thanks to a French-American architect, great brawn thanks to Henry Ford and the industry he spawned, and great brains thanks to a world-class metrocampus of educational, medical, automotive, design, and high-tech institutions. It is an exciting and eclectic mix, and so too was the makeup of the HealthQuake delegation.

Delegates discussed the current and future state of healthcare in the context of the convergence of health and technology through new forms of medicine collectively labeled *postmodern*. Taking *regenerative medicine* as representative of postmodern medicine as a whole, delegates discussed its potential impacts and implications for health policy, practice, business, research, commercialization, and education. By design, the delegation represented all of these sectors.

As an edited compilation of their presentations and remarks, this report is attributable to all delegates in the sense that each contributed some part to it, but responsibility for the whole must rest solely with the editor. Not every delegate may agree with every statement made herein, though we have tried to capture the sense of the delegation as a whole.

In addition to the discussion summary, this report contains a brief introduction to postmodern medicine to provide the context, and the list of delegates.

I hope to welcome you to Detroit for HealthQuake 2018. It will again be an invitation-only event, but bigger and longer. The issues discussed at HealthQuake 2017 and raised in this report are only going to grow more salient, at an accelerating rate.



J. Edson Pontes, MD
Chairman
Detroit International Research & Education Foundation

INTRODUCTION

Technology and healthcare are two "tech-tonic" plates converging so fast that the result amounts to a "HealthQuake." The goal of the 2017 HealthQuake Summit was to identify critical areas and issues facing the business, practice, and governance of healthcare thrown out from the accelerating, HealthQuake-induced, maelstrom into which science, research, the economy, society, education, policy, politics, ethics, the law, and other aspects of life and business cannot avoid but be drawn to converge with one another. Thus, the HealthQuake is also a convergence of industries and professions, as reflected in the eclectic group of delegates who attended the inaugural HealthQuake Summit on May 22, 2017 at the Westin Book Cadillac hotel in Detroit.

In a maelstrom of accelerating convergence, it is no longer that the big eat the small. It's that the fast beat the slow. But for many hopeful innovators in healthcare, institutional inertia, insufficient research and development infrastructure, and patent regulation act as brakes that impede (though they cannot stop) the convergence. For those who persevere long and hard enough to wear out the brake pads, the reward from innovation can be substantial not only to themselves but to the whole economy as well: In 2006, the National Bureau of Economic Research estimated that every dollar spent on medical innovation saved $7.20 in medical spending.

However, past performance is no guarantor of future success, especially in light of the brakes on innovation, and there are a number of areas of concern to which we need to pay attention (see Boxes 1 and 2). The primary focus of attention must be on

Box 1: Areas of Concern

1. The 2.3 percent excise tax on medical devices established in 2012 is estimated to cost about 46,000 jobs and is held by some to discourage entrepreneurial innovation. The American Health Care Act would scrap the tax.

2. The FDA process is so bureaucratic and slow that some US manufacturers have had their products approved through the European regulatory regime instead.

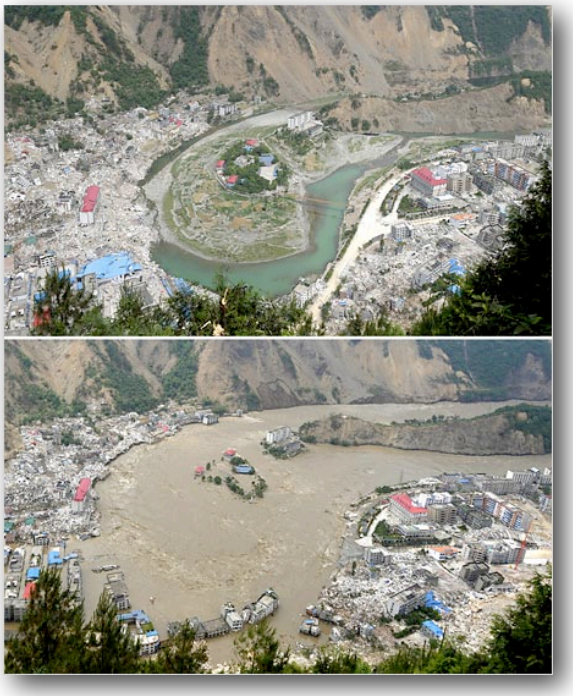
3. Uncertainties over:
   - The future of the Research & Experimentation Tax Credit for companies that incur research and development costs in the United States, which has to be reviewed annually
   - Cuts to the National Institutes of Health (NIH) budget
   - The loss of independence by the Agency for Healthcare Research and Quality (AHRQ) resulting from its proposed takeover by the NIH

4. The ethics of some aspects of postmodern medicine. For example: Embryonic stem cell therapies seem to required people to choose between two moral principles: To alleviate suffering, or to respect the value of life.

Box 2: Innovation Competition

- The world's top innovators in general are the US and Japan
- The world's top innovators in biotechnology are the US and Denmark
- The world's top innovators in medical technology are Israel, Denmark, India, the UK, and Sweden. The US is number 6.
- In IT, the US ranks as number 5.
- In 2016, the US Patent and Trademark Office was taking an average 16 months to approve a patent. The top patenter in terms of countries by far was Japan.

Figure 1: Beichuan Before and After



health information technology (HIT), estimated by the McKinsey Global Institute to create more than $300 billion in value every year and reduce healthcare costs by eight percent annually. HIT is emerging as one of the most potent drivers of healthcare, and is one of the key tremors arising from the HealthQuake that will result in a healthcare system unrecognizable in 15–20 years.

A Call to Action

The main difference between the earthquakes that struck the cities of Beichuan in China and Kobe in Japan in recent decades was not so much their magnitude but more the amount of damaged they caused. Beichuan was demolished and 70,000 people died; in Kobe, a few buildings were damaged and about 5,000 people died. Kobe was prepared; Beichuan was not.

The tech-tonic plates of healthcare are moving at an exponential rate, threatening to wreak HealthQuake havoc on unprepared institutions and individuals. Two key technologies driving those plates are the Internet of Things (IoT) and cloud computing. The latter puts the medical IoT—including an exponentially expanding array of wearable and implanted health technologies—at every everyone's service via the smartphone, the cloud, big data, and advanced intelligent analytics.

The IoT is a growing key component of HIT, and HIT is central to medical advancement. But it is often noted (often enough to be credible) that the healthcare industry is behind other industries in developing and applying HIT. It has access to vast stores of patient data in EMR silos and in the IoT but is not yet applying the big data analytic tools other industries apply to their data. The focus is on what is easy to measure rather than on what is important to measure. And not all provider facilities even have an EMR, which is partly a function of the extraordinarily high cost of EMR systems. It's a challenge for providers to know what's going on with their patients because they have access only to their own data, not that of others.

A more salient or less hidden tech-tonic force is one made up of new forms of medicine collectively called "postmodern" (see Box 3). This inaugural, one-day HealthQuake was too short for adequate discussion of all forms of postmodern

medicine, so one form was chosen as an exemplar representing—in terms of impact—the whole: Regenerative medicine.

Box 3: Postmodern Medicine

Physicians are starting to practice forms of medicine difficult to classify under the biomedical schema that held throughout the 20th century. The new forms, which we collectively label "postmodern," include:

Regenerative medicine – repairing or growing tissues, organs, and limbs inside the body (or on the body, in the case of limbs) or in the laboratory for implant or transplant. The main tools of regenerative medicine are cellular therapies (in particular, stem cell therapies), tissue engineering, and genetic engineering. Current successes include tissue-engineered bladders implanted in children, and under intense development are tissue-engineered heart, liver, bone, blood vessels, trachea, kidney, bladder, salivary gland, breast, ovaries, skeletal muscle, smooth muscle, pancreas, lung, cartilage, nerves, esophagus, ureter, urethra, teeth, genitalia, and testes.

Bionic medicine – repairing or replacing tissues, organs, and limbs with artificial "bionic" devices. Bionic people ("cyborgs") exist in the form of people with heart and brain pacemakers, hip implants, hearing implants, and robotic prosthetic limbs. Under advanced development are artificial implantable eyes, nose, liver, pancreas, kidney, heart, muscle, bone, and more.

Mitochondrial medicine – treating mitochondrial defects that in turn cause or facilitate diseases from neurological disorders to diabetes.

Genetic medicine – diagnosing and treating patients on the basis of their unique genomics. Pharmacogenomics (tailoring drugs and doses to the specific patient's genome) is one aspect of genetic medicine. The sudden availability of fast and cheap CRISPR gene editing in 2015 (a tremor in itself) has boosted R&D enormously and already has had successes in treating disease.

Digital medicine – treating mathematical models of actual patients, before treating the actual patient, using rapidly evolving tools such as "systems biology" aided and accelerated by exponentially growing computing power and artificial intelligence. The last bottleneck impeding efficient and inexpensive discovery of drugs, particularly in the age of pharmacogenomics is the clinical trial, which can cost hundreds of millions. By mathematically modeling body systems and functions and apply a mathematical model of the drug to it, a drug that will work for the individual can be precisely formulated.

Postmodern surgery – operating on patients non-invasively through radiological, regenerative, nanoscale robot, and other means; or invasively to implant bionic devices or lab-grown organs and tissues. Most procedures will be performed by autonomous, integrated OR equipment such as computer-controlled, image-guided stereotactic surgical robots.

REGENERATIVE MEDICINE

Over the past 20 years, demand for organs for transplant has increased six-fold, but there has been no increase in supply despite a growing population living longer lives. Nevertheless, it is not science fiction to think that we may one day eliminate the supply problem entirely through regeneration. In fact, we have the ability to regenerate our own organs—and even limbs—using cells alone (for example, spray-on skin, which is in clinical trials now), or cells plus a scaffold (for example, bladders, which have been regenerated and implanted in patients for several years). Work is underway on solid and complex organs such as regenerated livers, kidneys, and hearts.

Work is also well underway to replace the manual construction of organs with an automated 3D printing process. This, and other technologies of regenerative medicine, has also enabled the production of

Box 4: Really Regenerative?

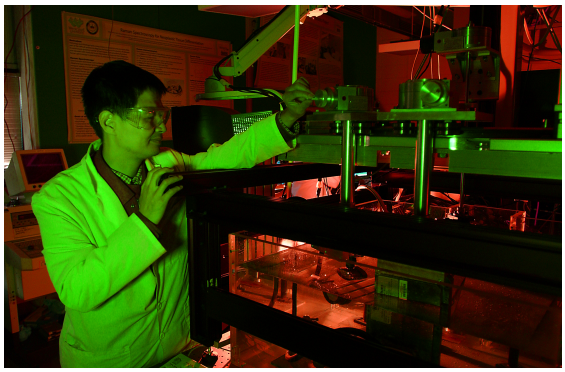
It has been suggested that *in-vivo* regenerative medicine using bone marrow, PRP (platelet-rich plasma) cells, or fat cells (e.g. for knee pain) is another way forward. Unfortunately, this is not really regenerative medicine. Such cells are not incorporated into tissue and do not turn into the target tissue. They do release growth factors that reduce inflammation and may thus improve healing, but that is no better than a steroid. True regenerative medicine would use healthy cells from the target tissue in the patient. However, some cells (liver cells, nerve cells, pancreatic cells) cannot be grown outside the body.

organelles—parts of whole organs—that can be used, for example, for testing patient-specific drugs. The technique involves printing cells, layer by layer, onto a chip. It will quickly discover whether or not a drug is toxic or beneficial to the patient and eliminate the need for multi-million-dollar clinical trials, which are obsolescent in a world adapting to precision personal medicine.

Embryonic stems cells and induced pluripotent stem cells (derived from adult cells) have real potential in regenerative medicine. Unfortunately, they have a tendency to produce tumors, and are useful mainly in research. Stem cells found in fetal cord blood do not form tumors but are difficult to grow in quantity and are more limited in their ability to turn into other cell types. Cord blood cells are only good for patients with blood cancers such as leukemia, and if the patient is older than 12 or 13, two cords-worth of blood are needed. Stem cells from amniotic fluid and the placenta, however, have the benefits of both embryonic/adult and cord blood stem cells but none of their drawbacks. Amniotic stem cells have been successfully converted to pancreatic cells, and several clinical trials are underway.

Following the announcement of the development of amniotic stem cells in 2003, the White House and the Vatican both issued statements pointing out that there were now alternatives to embryonic stem cells, though bills introduced in Congress to start a national amnion-derived stem cell bank went nowhere; however, a donor subsequently gave $10 million to start an amnion bank, available at no charge to anyone.

The paucity of US government funding for research and commercialization of regenerative medicine (representing postmodern medicine as a whole) was one of several issues addressed by Summit delegates.



RESEARCH & COMMERCIALIZATION

20 or 25 years ago there was no National Institutes of Health (NIH) funding for regenerative medicine research. The head of the NIH refused to fund what he regarded as “science fiction.” The NIH today still funds predominantly low-risk research. And since it funds only 9–10 percent of

grant proposals, statistically it takes ten submissions to win one grant. Each takes hundreds of man-hours to write. This is not the best use of researchers' time. We need a better system.

Should we fix the existing system or create a whole new one? Perhaps the answer is clearer if we retain a focus on the patient. Is the length of time taken for grant approvals, for example, good for patients? Could industry, with its immediate access to capital, be willing to share some of the risk earlier if academia were to involve it sooner?

NIH's low-risk approach may be reflected in the fact that no randomized controlled trial has yet produced a cancer drug that cured anybody. Gleevec added years of life for some leukemia patients, but the vast ma- jority of cancer drugs have at best increased survival by only weeks on average. Other things (such as ethics) being equal, taxpayers probably would not mind paying for research that results in real benefits, but much of their money goes in the form of NIH grants to fund research that results in marginal incremental benefits at best.

Part of the reason for the perpetuation of this situation is that academia depends heavily on the indirect funding it receives from NIH and other grants awarded to conservative researchers, so it discourages hard-to-fund, cutting-edge research by denying tenure, etc., to innovative academicians. We need a new funding mechanism, preferably not taxpayer-funded. Unfortunately, industry also tends to be somewhat risk-averse. Wake Forest's Institute for Regenerative Medicine patents every technology, including the regenerated tissues, it creates. The availability of intellectual property rights reduces the risk for industrial enterprises wishing to invest in them.

Some universities have done well financially from patented innovations, but they are few and far between. Harvard received considerable revenue from licensing its patented anti-angiogenesis technology. The University of Florida makes $12 million a year from the patents on the technology that became Gatorade. The University of Wisconsin makes tens of millions annually by out-licensing its patents on vitamin D, warfarin, and stem cell lines. That's wonderful for Harvard, Florida, and Wisconsin, but many institutions miss out on such opportunities because they are so focused on NIH funding. The university that created the life-saving compound that became the blockbuster AIDS drug AZT—which earned billions for the company that patented it—neglected to patent it first.

Traditional pharmaceutical companies are in the (so far) lucrative business of providing blockbuster "one-size-fits-almost-everybody" drugs like aspirin or statins. Postmodern medicine promises bespoke, personalized, precision cures. Pharmaceutical companies initially sought to join the revolution by acquiring innovative biotech startups. But they found that the acquired technologies did not do well in clinical trials, and ended up effectively shutting down the research. It was not fully understood that many conditions (like

cancer) come in many forms and sub-forms and are treated differently by individuals with slight genetic differences. In retrospect, it would have been better for the NIH to have invested in further research before allowing those clinical trials to proceed. We all want to get effective new treatments to patients as fast as possible—everything should start and end with the patient—but first we must make sure the treatment works to create transformational change in the patient before we take it to a more receptive industry for commercialization.

The Wake Forest Institute for Regenerative Medicine has a GMP (Good Manufacturing Practice—certified consistent high quality in drug production) facility enabling it to take technologies all the way from initial concept through to small-scale manufacture for clinical trials. It also has the ability to conduct its own phase I and II clinical trials. This concept-to-cure model is not what a typical startup would do. When technology is transferred to a startup at too early a stage (as is the usual case) the startup becomes mired in managing intellectual property, creating a business model, analyzing the reimbursement landscape and the competitive landscape, and so on. In contrast to this linear model, Wake Forest has a development group that works in parallel with the research group, in order that technology is not transferred unless and until these various issues have been worked out.

If government—in particular, the NIH and the Food and Drug Administration (FDA)—and academia seem slow and too risk-averse, industry seems shortsighted, too focused on the quarterly report. Research is beyond the purview of most businesses. But if companies helped co-develop a technology from the beginning and participated in the IP from the beginning, they might be less purblind. Now, they wait until a market is almost established and very competitive before dipping a toe in.

POLICY

Even when R&D on unproven experimental medical innovations is funded, there is an ethical tension in using them for humanitarian purposes. To date we have been good at keeping alive people who served in the Vietnam War, but unless some current experimental regenerative therapies are made available to them, many may well die. That said, it would be wrong to fault the FDA for its reluctance to do this while also rushing to condemn the FDA when something goes wrong with something it passed for use under the humanitarian device or orphan drug exemptions. Time is the problem: It takes an average of 15.1 years from the start of its phase 1 clinical trial for a pill to be approved by the FDA.

This tension between tardy supply and urgent demand needs further scrutiny and resolution, if not for the Vietnam vets, then for the “When do we want it? NOW!” generation. Efforts in that direction—the Faster Cures initiative, the Bipartisan Policy Council’s attempt to get the FDA to relax regulation of regenerative medicine, as well as the REGROW Act and the 21st

Century Cures Act—have had some success and are moving us in the right direction. There is also a move toward better risk assessment based on the knowledge gained from Phase 1 trials, and toward allowing patients to receive treatments sooner if they accept the better-assessed risks.

Notwithstanding all of this, however, the HealthQuake could render current regulations moot in ten or so years. Drug and device approvals might be given based on digital medicine applied to big data in the cloud, or based on a clinical trial with an *N* of 1 (the actual patient) using organelles-on-a-chip to test for safety and efficacy.

The growing tension between supply and demand for effective treatments and the constructive deconstruction wrought by the HealthQuake mean that clinical trials must and eventually will be rendered obsolete. This claim is not so outlandish given that, only 25 years ago, respected people referred to regenerative medicine as "science fiction."

Although payers including Medicare and Medicaid seek to approve technologies that promise to decrease costs and are correspondingly reluctant to approve technologies that increase costs, an increasing percentage of the tax dollar nevertheless goes to fund healthcare, and that seems unlikely to change any time soon. Technologies that increase longevity have been successful and will continue to be so. The question is: How to provide such technologies appropriately and ethically for the people who need them? Who can afford the technology if government does not pay—which it will not, unless the technology is safe?

We need an NIH leadership willing to reduce the emphasis on safety—it is not, after all, the FDA—and allocate funding for innovation. But that raises the issue of ethics.

ETHICS

There is no ethical push-back against regenerative medicine that uses the patient's own cells. However, when bionic and genetic modification are added to regenerative medicine there is the possibility of creating super-organs and hence a superhuman. Though this is not the goal of reputable labs, they nevertheless treat ethics very seriously, to the extent (in the case of the Wake Forest Institute for Regenerative Medicine) of having an ethicist on staff and of not implanting an engineered tissue or organ into a patient unless all members of the team agree that they would be willing to put it into their own child, parent, spouse, or any other loved one.

Wake Forest competes against disease, not against other institutions. The Institute collaborates with over 240 national institutions and 70 international institutions. In most cases the collaboration involves freely giving reagents, cells, material, and knowledge to the collaborator, because the Institute wants the whole field to succeed. Patents notwithstanding, there are no secrets. In its armed forces program, the Institute wants to get

its technology to wounded warriors, and every collaborator wants the same thing—nobody wants to put obstacles in the way of life-saving treatments for heroes. So teams of potential competitors turn into teams of focused collaborators, turning the usual consortium model on its head.

The overarching ethic in postmodern medicine is "Above all, do no harm." The Vatican's chief ethicist, who happens to be a transplant surgeon, has called for balancing the need to find new treatments with that principle. In fact, transplant patients are already prioritized for surgery according to their need, rather than on the basis of their ability to pay.

MEDICAL EDUCATION

Medical education today faces incredible challenges. Academia, so dependent on NIH funding, is waiting for the guillotine to drop on that funding at a time when medical education has never been more expensive. The United States is the only country in the world that doesn't require any minimum competence in its medical graduates—while saddling them with enormous debt. There is a drive to relieve student debt by reducing the medical school curriculum from 4 years to 3 years.

People complain that med schools are not teaching students enough about medical ethics, or hospital administration, or healthcare policy… a myriad things; but there is only so much time. The emphasis today is less on factual knowledge and more on turning students into lifetime learners, stimulating their curiosity and giving them the means to satisfy it.

Already, residents don't bother to memorize the details of many diseases, knowing they can look up the details on their smartphones when a disease is presented. Education is no longer about memorization: It is about teaching a love of learning coupled with a sense of responsibility. It is about giving students the tools to learn and responsibly apply that learning to solve the problems of patients.

Curriculum

We must therefore adapt the medical school curriculum, as well as medical practice, to the technologies available today. The challenge is how to adapt and utilize the new technologies in a meaningful way. Most physicians today no longer keep up with the literature of their field. This puts them at risk of failing to be re-accredited after five years. We need to address this, but the literature in their own field is being encroached upon further by the literature of other fields; in particular, bio-engineering.

Is it not high time for biomedical engineering to be added to the medical school curriculum? It will always remain true that the prime responsibility of medical school is to give students a foundation of knowledge. They must learn the basics. If we erode that foundation—and we are at high risk of doing so—then we are in trouble. Even so, it must be acknowledged that the medical education model in use today was developed at the end of the 19th century,

yet the physicians educated under that model increasingly practice a totally different form of medicine from the one they were trained in. The work of a radiologist who has become an innovator in 3D ultrasound and cryotherapies has little to do with the chest x-rays he was taught in med school.

How do we train people under such changing conditions? And what about the technologies that will be available and the conditions that will pertain tomorrow? The half-life of medical knowledge is shrinking exponentially. What a student learns at the start of med school will be out of date by the time s/he graduates. We have to change from assessing students based on their memorization of 10-year-old knowledge, to assessing their ability to organize and apply current knowledge in real time.

Box 5: Tech-tonic Take-over

CBS News recently aired a short piece showing a smart phone app (Face2Gene) that uses the same face-recognition algorithms as Facebook against a database of faces of children with some 8,000 rare genetic neurological disorders. It can make a diagnosis in seconds. A second simple technology uses infrared tracking technology to quickly diagnose autism in children (RightEye). It replaces a long and complex process of lab tests. The head of Face2Gene said that although his app itself was available to download freely, the database was only accessible to doctors, on the grounds that parents could not be trusted to treat the system responsibly. That may be justifiable today, but eventually, when it becomes always accurate and reliable, it should be accessible to all. We need genetic counselors to explain the results of genomic testing to patients. Patients already consult the Internet before visiting their doctor. It sometimes misinforms or confuses patients, but over time it will get better, and we will not be able to control patients' use of it.

There is no other way they can keep up with changes in diagnosis and treatment.

Simulation

Simulation may be central to assessment and indeed to a postmodern paradigm for medical education, though simulators today are expensive and raise the costs of tuition. A key role of simulators will be to assess physician competency, but beyond measuring basic proficiency and patient interaction skills of surgeons and interventionists, simulators could eventually become sufficiently skilled to return us to the old apprenticeship model. And yet, if a simulator (which, unlike a physician mentor, can easily be replicated) can simulate the physician mentor, then who needs apprentice physicians?

Computers can help doctors to make differential diagnoses but are not yet sufficiently reliable to be allowed to do so autonomously. IBM's Dr. Watson is already helping to diagnose cancer but is still near the bottom of its curve of capability. But recall that the curve is exponential, then imagine what Dr. Watson—and its inevitable competitors—will be able to do in ten years' time.

PRACTICE

Physicians have been somewhat notorious for their variability in diagnosis and treatment, and for the time being Dr. Watson, Face2Gene (see Box 5) and other technologies will help to decrease the variability. But when the validity and reliability of machine diagnosis exceeds that of physician diagnosis, even only marginally,

patients will prefer it. That includes patients in the less-developed world, who will at least have smartphones connected to the Internet (and therefore to Dr. Watson) through the low-cost satellite systems under current development by Google, Facebook, and probably others.

Clinical knowledge alone is not always sufficient for good diagnosis and therapy. Doctors are not taught social skills sufficient to help them determine the social determinants of their patients' health. A patient might be non-compliant with her meds because she does not have a refrigerator to store them in. The role of the physician needs to change as technology-aided patients assume greater responsibility for their health. It could certainly be broadened to encompass the social determinants, and there is indeed some movement towards that now. Even here, though, technology can assist—and, ultimately, replace—the doctor in assessing the social determinants of a patient's health. Wearable or other telemedical sensors prescribed for the patient will inform the care system, human or machine, that the patient does not have a fridge.

But an IoT-connected fridge will only tell the doctor it is broken if it still has power to communicate. This was one reason why some delegates felt we should not rush to write off the role of the physician. The three-year med student may be less capable than the four-year student, having had less experience with patients, but will still be better than technology that's dead because the power has been cut. Physicians need to connect with patients to learn about their culture and how they might therefore respond to treatment. Perhaps we should not let technology take charge, but keep it in a subordinate, helper, role. In this human master–machine subordinate model, the subordinate's speed gives the master more time to spend communicating with the patient.

Still, the genie might never be got back into its bottle of subordination. Technology seems to accelerate up its exponential curve whether we like it or not. We have little control over it and therefore little control over the rate of change. It may not be a matter, then, of fighting the genie or employing it as an assistant. It may be more a matter of engaging with it and trying to anticipate and (to the extent possible) steer the changes away from being threats and towards being opportunities. The role of the physician will change, and indeed it might well involve a closer connection with the patient.

But is that not, after all, what has always motivated most physicians to enter their profession? If so, why should they want to avoid the impacts of technologies which help them get closer than ever to the patients they care for? The challenge is how to weed out the clinically less capable, but better marketed, technologies; and the answer perhaps lies in having a trusted human source—the doctor—be the judge.

THE HUMAN TOUCH

But will patients, especially those raised in a world of texting and interfacing via Skype and (before long) holohaptic interfaces, always want the personal, human, touch and the education-and-experience-based judgment of the doctor or nurse? Older people might not trust the autopilot or the autonomous vehicle, but the younger generation may trust it more than the pilot or the driver. Autonomous vehicles will certainly be a benefit for the elderly who can (or should) no longer drive, and will reduce the number of patients because there will be fewer accidents.

It is harder for older physicians to accept the coming changes in their world, but it will be easier for the next generation now starting to take over that world. Already, as noted, education today assumes that the student has knowledge because knowledge is instantly available over the Internet, and seeks to focus instead on teamwork and critical thinking skills. But that is hard for older professors to accept. The automobile industry faces a possible world where few people need or want to own a car or bother to learn to drive. As the success of Uber and Lyft demonstrate, people today just want to be able to get efficiently from A to B while remaining free to focus on things other than driving and parking, and will do so tomorrow with autonomous Lyft and Uber vehicles; only, *sans* driver.

The healthcare industry is not immune to similar disruption. The new world starting to be inhabited by the younger generation consists of devices and smartphones that measure health activity, perform EKGs, scan pills to identify them, conduct a sleep lab, diagnose patients remotely, and much more. Technology sometimes does these jobs better than doctors, especially when it comes to the uncommon conditions that add most cost to the medical system and provide the worst patient experience by requiring multiple tests and opinions.

We should not stop this new world even if we could. Doctors used to get upset when people came to their office armed with printouts from the Internet, but today, most doctors welcome it. Biomonitoring apps—the machine subordinates of our time—provide more information in less time. They do not detract from the physician's

service—they simply add to the physician's toolbox by providing a continuous flow of data in real time showing whether the patient is compliant with medications, her current vitals, his arrhythmias. The data deluge is manageable thanks to the kind of "big data" advanced analysis and prediction in which Dr. Watson is a pioneer.

HOSPITALS & BUSINESS

Is there, then, really an opportunity to enhance, instead of replace, the role of the doctor? Conceivably, the new world technologies could steer the patient away from the emergency room and toward the primary care physician, or away from unnecessary visits altogether. The fact is that the traditional primary care physician's office has already been disrupted. The physician just doesn't know it yet. The young generation of patients simply will not put up with the service model today's older generation puts up with: Long waits for appointments, meaningless appointment times, and so on. People want immediate gratification and expect immediate service. Healthcare institutions could do a lot to improve the patient experience, but whether they do or don't, technology will empower patients to improve their own experience anyway.

The difficulty is that the healthcare system today is transactional at its root and annual at its best. Drugs are often sold at a fraction of their net present value. Down the line, this shocks the system, because it has no concept of net present value—of the notion that something may need to cost a lot more today in order to save money in the future. This lack of financial understanding is endemic today.

A sign of the brokenness of healthcare is that in most hospital systems, no single payer has one single patient for the patient's whole life. So smoking cessation, for example, is not calculated on the basis of a lifelong projection but only on the payer's annual or even quarterly projection of benefit. Treating patients on a lifelong basis would amount to transformational change.

The rapid growth of telehealth (also still near the base of its exponential curve) is a result of patient demand, not provider push. Hospitals lose patients today because of the service experience. The 18- to 44-year-old generation uses the hospital mainly for obstetrics. At age 44, utilization diversifies and goes up dramatically. We need to do a better job connecting to those aging "high rollers." The boomer generation can adapt to the new technologies; they are not only for millennials. If the patient experience is better, every patient—young or old—will migrate to it.

The problem of hospital high rollers and frequent flyers is less a failure to acknowledge the social determinants at the heart of much of it. The problem is more a failure of the payment system to support ways to address the issue of social determinants. There are some small local models that incorporate social determinants, but they are not at scale. Government innovation grants are sometimes available to handle frequent flyers, including home visits, but once the grant funds are used up there is no ongoing payment mechanism and the experiment ends.

Poverty is the basic social determinant of health. There is a direct correlation in poor communities between hospital re-admissions and the length of time it takes discharged patients to visit a primary care physician following discharge. The longer they wait, the more likely they are to be re-admitted. The problem, it turns out, is transportation—poor patients cannot afford transportation to go see the doctor. But hospitals may not provide transportation because of anti-kickback laws.

This is just one of many policy contradictions, despite a genuine willingness among policymakers to try to do the right thing. Europe has more uniform policies. The French multinational corporation Dassault Systèmes has a telemedicine program for employees discharged from hospital. The United States could learn from such models. But first it must fix the payment model.

The payment model was not always broken. The United States used to have public health clinics and nurses who would make home visits, but they disappeared when Medicaid and other kinds of payment sources came in. The payment system is the driver, and the payment system has driven those clinics and nurses away. Increasing competition drove up the cost of care at the expense of spending on public health, and politics diverted money away from public health. The politics were and still are based on many questionable assumptions, such as about patient compliance, demand for nursing home care, and so on.

Hospitals are responsible for providing a screening exam to anyone who shows up in the emergency room. One administration decided this amounted to universal healthcare and on that basis declined to extend the State Children's Health Insurance Program (S-CHIP). There is much misperception and misassumption regarding access and financing, regarding coverage and financing. All the incentives today are aligned against discharging patients quickly so they can be monitored and cared for in the inexpensive comfort of home. Nevertheless, we should recognize that patients themselves have some responsibility for their own care.

How much time is spent looking at these immediate pressing issues compared with looking to the future? Technology seems to force planning horizons ever closer. Hospitals buy technology based on ROI and NPV. Planners scratch their heads over whether a purchase will be worth it over time, while pundits shake their heads if

someone announces a $2 billion hospital building program, especially since the decline in ACA coverage. Nobody spends enough time on the intangible future because they have so many tangible battles to fight.

One of the most crucial battles is the budget. Budgets drive planning and forecasting. States control Medicaid budgets through three levers: (1) They define the eligible population; (2) they define the service provider; and (the lever most used) (3) they determine the provider payment. It is easier to cut the provider payment than to cut services or the eligible population. Most of what drives public legislation in terms of passing bills is cost and the need to balance budgets. Politics determines the priorities, and health is not seen as a priority by the current administration.

A hospital or any company that looks to the future will tend to prioritize R&D more than one that does not. R&D consumes a significant portion of a foresighted company's controllable budget. It is important to the modern business growth model to be on the leading edge of providing technology solutions, rather than just turning out commodity products. Established companies tend to grow conservative, and conservative companies are more reactive than proactive. They prefer to budget money for incremental improvements to their technologies rather than on R&D. These are companies ripe for disruption by companies more in tune with the technologies that are going to change market needs.

Consumerism

Middlemen in healthcare often survive only because of misguided legislation. That alone makes them ripe for disruption, but even more threatening is that they face the prospect of elimination as technology facilitates direct links between healthcare consumer and provider.

Technology-empowered consumers may constitute the most disruptive and transformational force in healthcare, more so than payers or providers. Payers are really buyers, though they don't act like it. Perhaps that's because actually it's patients, not payers, who pick up the cost of overexpensive drugs. Still, payers are starting to negotiate prescription drug prices with the pharmaceutical companies and may have some disruptive effect. Expecting patients to take ownership of their care management when they cannot afford medications and treatment is unrealistic, but technology-empowered consumerism is starting to make care more affordable.

Will the assumption by patients of more responsibility for their own care correspondingly decrease the responsibility (and liability) of professional care providers? Will it affect malpractice suits? When patients visit their doctor having first prepared by researching their condition on the Internet, it allows more time for discussion about the patient's options. They are better informed, though that may make them more fearful. Setting realistic expectations (as, for example, about survival chances) is very important. Decisions need to be aligned with what is best for patients.

The "Strong for Surgery" program of the American College of Surgeons brings a presurgery checklist to surgeons' offices to help with education, communication, and standardization of best practices to improve clinical outcomes. Its effect is to optimize the patient for surgery—it makes sure patients exercise and eat proper nutrition beforehand. To wait until after surgery to do this is to close the barn door after the horse has bolted.

All proactive, accountable providers concerned more about outcomes than about malpractice suits should and do create educational materials—information sheets, website with videos, links to other good health resource websites, etc.—and encourage patients to consult these resources before or after their visit (as appropriate).

A poor outcome by no means necessarily indicates provider malpractice. Patients' own decisions and behavior have an impact also. But sick people are vulnerable people. While it must be remembered that patients may be vulnerable and their judgment impaired, technology can reduce their vulnerability by (for example) overcoming language, cultural, and other barriers to self-management accountability. We tend to deny acts of God. We assert instead that everything has a discoverable scientific cause. Doctors are only liable for a poor outcome if they fail to do what a reasonable subset of doctors would do. As we amass more data, what the reasonable subset would do is liable to change. Practice guidelines will change, and what constitutes informed consent will evolve. Different patients, with differing degrees of sickness and vulnerability, absorb the contents of an informed consent form differently.

CONCLUSION

The Acceleration of Innovations

In an era of accelerating and now almost daily breakthroughs in medical technologies (see Figure 2 on p.17), the only thing surprising is surprise itself.

The breakthroughs involve not just postmodern medicine. Other accelerating contributors to the maelstrom include the simplification, automation, and globalization of healthcare, and the inexorable drive to the defeat of chronic disease and even, ultimately, of death.

Over time, its organizers hope that HealthQuake will serve to reduce the "time to insight" (a phrase coined by Microsoft's former chief strategist Craig Mundie) of those to whom it falls to assess the impact of those breakthroughs which are the result of the accelerating convergence of health and technology.

Toward HealthQuake 2018

The future is present today, as it was always present in the past. It exists, as it has always existed and will aways exist, in our imagination.

Imagination is the common denominator for the collective imagination we call myth and the individual imagination we call dream. People have dreamed of leg trans-

plants for thousands of years, as we know from ancient paintings.

The face is more complicated than a leg, with some 20 muscles having to coordinate with one another and with an extensive structure of nerves and blood vessels. Yet face transplants were imagined, and have now been done using faces from cadavers. The 3D-printed faces we imagine today may be a reality in 20 years. Even whole head transplants are not unimaginable, and are therefore not beyond the realm of possibility.

Imagination is key to predicting the HealthQuake and its impacts. Had cardiothoracic surgeons dared to imagine the interventional cardiologist, keyhole surgery, and stents, they might have been spared their near-demise. Their experience, together with the emergence of the smartphone app (like Face2Gene) as a reliable, inexpensive, and instantly accessible care provider, should be sufficient to disabuse anyone of the notion that physicians are immune to rapid obsolescence. When obsolescence starts to affect not just one specialty but the whole spectrum of medicine and its professions, the business of healthcare must and will change drastically. The question is how fast, how far, and in what direction? HealthQuake 2018 (see Box 6) will try to introduce some level of certainty by predicting the range of potential changes in terms of time and magnitude.

Box 6: HealthQuake 2018
A Look Ahead

Theme: "The Convergence of Medicine and Technology" will remain the theme for 2018.

Venue: Detroit—a major medical hub and center of healthcare research, innovation, and practice, and a beautiful city located—believe it or not—north of Canada.

Dates: To be decided; May–June, 2018

Scope: 100 delegates, 4 working groups.

Activities: May include visits to The Henry Ford Museum, the Ford Motors Rouge River plant, a dinner/dance cruise on the Detroit River, and more. Delegate family members/companions are welcome and encouraged to participate in these activities.

Cost: Sponsorship-dependent.

Sponsorships: Actively solicited.

Exhibits: Businesses and academic/research institutions will be encouraged to exhibit innovative health technologies.

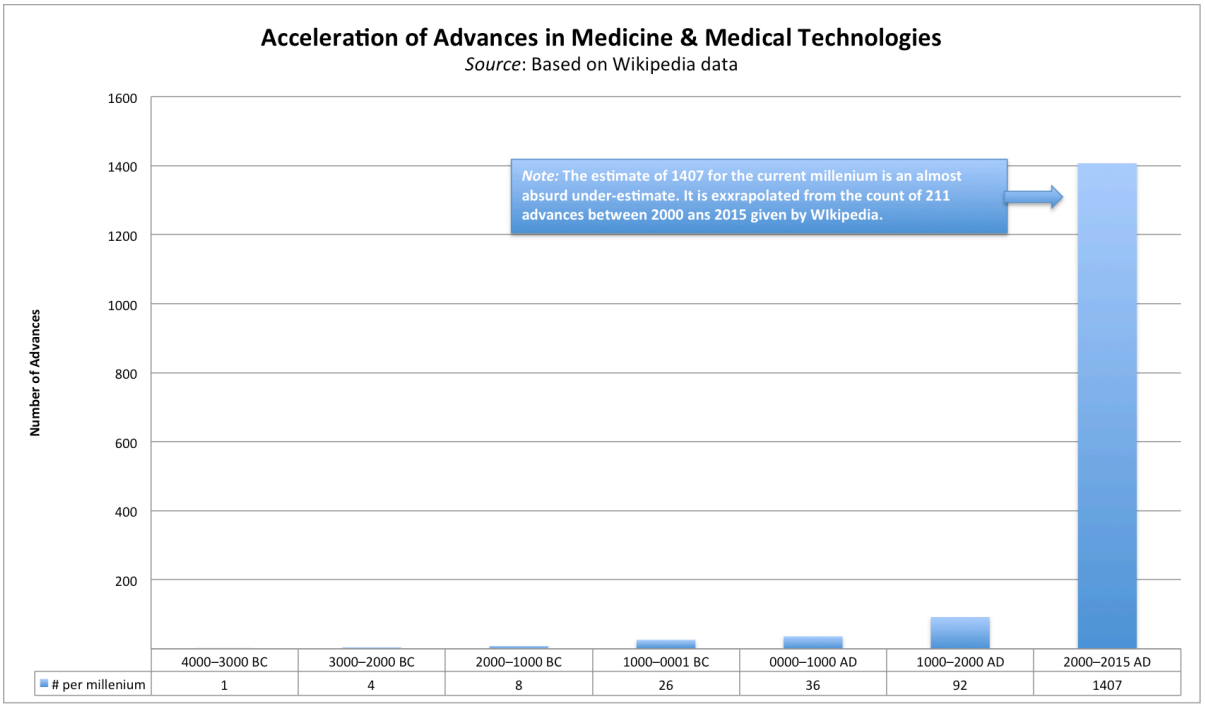
Topics will include: Ethics; Bionics; Hospital system strategic issues, Robotic surgery; Innovation funding/sources; Superhealth (e.g., in sports); *In-silico* biology; and more.

Delegates and Speakers: Will be invited from business associations (Business Roundtable, US Chamber of Commerce, etc.); Think tanks (e.g. RAND); Fortune 500 executives; government heads and congressmen/women; National Academy of Sciences; Insurance groups; young people/millennials; futurists; telemedicine experts; IBM (Dr. Watson); Celebrities in technology, business, entertainment, sports; astronauts/space experts; and more.

Please contact dellis@diref.org for more information on sponsorships, or with suggestions (better: introductions) regarding speakers, or ideas or requests regarding topics.

Thank you.

Figure 2: Acceleration of Advances in Medicine and Medical Technologies



A note on the source: The chart is based on data in the Wikipedia entry for "Timeline of medicine and medical technology" at https://en.wikipedia.org/wiki/Timeline_of_medicine_and_medical_technology. The entry lists events from the first recorded use of herbal medicine in approximately 3300 BC to the first human liver grown from stem cells in 2013.

Box 7: HealthQuake Tremors

A. Simplification

As medical devices appear to become simpler – though internally they are ever more complex – people with lesser skills can handle increasingly complex conditions, as the home defibrillator, home dialysis, and over-the-counter statins illustrate. Simplified technology plus growing availability of broadband also enables home monitoring of the frail elderly and chronic disease patients by remote caregivers.

Some sample implications:

- Policy: Predicted clinician shortages may not be as dire as claimed
- Practice: Sub-specialties, then specialties, then generalist clinicians will be replaced by less highly-trained professionals, or by the patient, or by an automated system
- Medical education: Will be in permanent and accelerating flux
- Regulation: Increasing workload for drug & device regulatory agencies to assess & approve new devices and OTC drugs, and patients and device/drug makers will seek to bypass regulation
- Hospitals: The roles of the hospital will shrink to trauma, intensive care, and bionic or regenerative enhancements to otherwise healthy patients

B. Automation & Robots

Science fiction creations are not uncommon in today's real world, and will be everywhere in tomorrow's. They will also be more intelligent, more inter-connected (wirelessly) with the entire technological infrastructure, and more autonomous. Hospitals have surgical robots, robotic baby seals for geriatric and pediatric pet therapy, and one has a robotic scrub nurse in the OR.

Some sample implications:

- Practice: Autonomous, intelligent, interconnected robots will replace humans at various skill levels, including surgeons and nurses
- Public health: Human lifespans may be extended well past the norm through the use of cyborgian implants such as artificial organs and tissues
- Policy: Cyborgian implants will exacerbate health inequalities between rich and poor

C. Postmodern Medicine (see p.7 Box 3)

Some sample implications:

- Policy, Financing, Practice: Clinical trials will not be necessary, saving time and money while improving the quality of care
- Policy: Animal trials can be eliminated
- Practice/Financing: Costly organ donor transplant programs, and the clinical, logistical, and sometimes ethical difficulties they entail, will be eliminated
- Policy, Medical education, Practice: Doctors will need to acquire and learn the tools of postmodern medicine
- Practice: Fewer surgeons will be needed, and those that remain will function very differently from today's surgeons
- HIT: With digital data assuming the central role in postmodern medicine, spending on HIT will grow substantially, and medical education must proactively engage with it

D. Globalization

Healthcare is still predominantly local, but the situation is changing rapidly. Radiologists in Australia, India, Ireland, and Hungary "read" (interpret) scanner reports from US hospitals. Surgeons in India, Thailand, Singapore, and elsewhere treat a growing number of patients willing to travel halfway around the globe for state-of-the-art treatment at fractions of the cost back home. Prestigious US hospitals such as Johns Hopkins, Mayo, and Cleveland are rapidly expanding their operations in other countries. Telesurgery is already being performed routinely by at least one surgeon in Canada, who uses a robot to perform complex procedures on patients hundreds of miles away.

Medical research, still predominantly a US and European preserve, is also going global. South Korea remains a force in embryonic stem cell research, so is the UK, and India and China are growing to be major players.

Some sample implications:

- Policy: Countries that restrict government funding for embryonic stem cell research may be ceding a key postmodern medicine to countries that do not

- Practice: Surgeons will have the capability to operate anywhere in the world, via telesurgery, at least until such time as fully autonomous postmodern surgical suites become ubiquitous
- Policy: Licensure and credentialing will require a radical overhaul to account for the globalization of healthcare (not to mention the new forms of postmodern medicine)

E. Defeat of Chronic Disease

A former head of the National Cancer Institute said that cancer would be essentially defeated by 2015. He was wrong, but he would have been right to say that cancer would be close to defeat. Many of the emerging technologies being successfully deployed against cancer -- monoclonal antibodies, RNA interference, pharmacogenomics, nanomedicines – also have application across all diseases, and the literature is increasingly replete with major advances, if not outright success, against some of our most prevalent diseases.

Some sample implications:

- Practice: The effective defeat of cancer, heart disease, neurodegenerative diseases, diabetes, or obesity will greatly reduce demand for clinicians
- Policy: To the extent that the provision of healthcare drives an economy, the sudden disappearance of demand will have serious economic ramifications across society

F. Longevity

Once we can fix or prevent almost any chronic disease or acute ailment, we can in theory go on living forever. But we will do better than that: By understanding the aging process itself at the molecular level, we will be able to control and manipulate the process.

Some sample implications:

- Society: With more people living longer and still productive lives, there will be more invention, more innovation, and perhaps even more wisdom in the world

2017 DELEGATES

(* denotes DIREF Board Member)

Anthony Atala, PhD — W.H. Boyce Professor and Director of the Wake Forest Institute for Regenerative Medicine, and Chair of the Department of Urology
Wake Forest University

Dr. Atala's work focuses on growing and regenerating tissues and organs. His team engineered the first lab-grown organ to be implanted into a human—a bladder—and is developing experimental fabrication technology that can "print" human tissue on demand. He was part of the team that showed stem cells can be harvested from the amniotic fluid of pregnant women. This and other breakthroughs in the development of smart biomaterials and tissue fabrication technology promises to revolutionize the practice of medicine.

Gregory Auner, PhD — Founder & Director
Smart Sensors & Integrated Microsystems Laboratory of the Michael & Marian Ilitch Department of Surgery, Wayne State University School of Medicine

Dr. Auner is the founder and director of the Smart Sensors and Integrated Microsystems Laboratory which encompasses five inter-connecting laboratories with over 11,000 sq. ft. of space. In partnership with Delphi Corporation, he established a 5000 sq. ft. class 100/10 clean room facility at Wayne State University. Dr. Auner has developed an array of instruments, sensors, and microsystems for federal and industrial R&D institutions. His research mostly involves the research and development of biomedical microsystems systems including implantable vision chips for the blind, an ultrasonic breast cancer detection system (since commercialized), and robotic end-effectors which enabled the first robot-assisted pediatric surgery in the world. Dr. Auner has over 20 patents issued and pending for chemical, biomedical, and environmental sensors and microsystems.

James Binson * Chairman
Binson's Medical Equipment & Supplies

Jim Binson is president of the company his father founded as a family pharmacy in 1953. The company grew to become a multifaceted supplier of durable medical equipment and supplies that give people an opportunity to meet their medical needs at home. This was a remarkably futuristic and prescient concept at the time, that turned into the multi-billion dollar home care industry. His lightbulb moment came when visiting his grandfather in hospital: “I looked at what was in the room, and there was a hospital bed, and an over-bed table, and I thought: Why can’t we do this at home?”

Robert A. Bohrer, JD Professor of Law
California Western School of Law

Professor Bohrer practiced with the Chicago law firm of Bell, Boyd & Lloyd before returning to academia. He focuses primarily on legal issues raised by developments in biotechnology and pharmaceutical policy. Professor Bohrer is a member of the executive board of the Biolaw Section of the Association of American Law Schools and previously served on the Council of the American Bar Association Section of Science and Technology. He has served as executive editor of *Biotechnology Law Report*, director of Biotechnology Programs at the University of California at San Diego's Center for Molecular Genetics, and member of the board of directors of the La Jolla Institute for Molecular Medicine. He was the only law professor to serve on the board of directors of the Biotechnology Institute of the U.S. Patent and Trademark Office.

Susan Brueckman * Senior Vice President
Huntington National Bank

Ms. Brueckman is regional manager of corporate affairs and chief of staff at Huntington National Bank. Previously, she was chief of staff at the Detroit Medical Center. Susan Brueckman serves or has served as a trustee of the Michigan Roundtable for Diversity and Inclusion, a director of the Arab American and Chaldean Council, a board member of the Detroit Golf Foundation, and a director of the Detroit International Research & Education Foundation.

Sheryl Connelly Manager, Global Consumer Trends and Futuring
Ford Motor Company

Sheryl Connelly has served as Ford Motor Company's futurist for more than a decade. She is responsible for identifying global trends, exploring potential implications and cascading these insights on futuring to organizations throughout the company, including design, product development and corporate strategy. She is a member of the Global Advisory Council on transportation for the World Economic Forum. Fast Company magazine named her one of the Most Creative People in Business in 2013 and 2015. Connelly has been a featured speaker at TED Global, appeared on CBS This Morning with Charlie Rose, CNBC's Fast Money and NPR's All Things Considered with Robert Siegel. Before working for Ford, she practiced law. In addition to a juris doctorate, Connelly holds a bachelor's degree in finance and a master's in business administration. When her schedule permits, she teaches design research at the Center for Creative Studies in Detroit.

Keith Crain * Chairman
Crain Communications

Keith Crain is recognized internationally for his contributions in both the automotive and publishing industries. He became publisher and editor-in-chief of *Automotive News* in 1971 and of *Crain's Detroit Business* when it launched in 1985. One of his major accomplishments has been the development of the Automotive News World Congress as an international forum for global business leaders to meet annually to discuss the most pressing issues facing the automotive industry. Mr. Crain also assisted in the development of the annual North American International Auto Show in Detroit in 1989. He went on to help with the launch of *Automotive News Europe's* European World Congress in 1997. His services to the automotive world were recognized by his Induction in 2014 into the Automotive Hall of Fame, the single greatest honor in the automotive business.

In addition to his commitment to publishing excellence and contributions to the automotive industry, Mr. Crain is active in a myriad civic and professional associations. His leadership positions include serving as chairman of the board of the College for Creative Studies. He also sits on the boards of The Concours d'Elegance of America, The Detroit Metro Convention & Visitors Bureau, Downtown Detroit Partnership, Gilmore Car Museum, the Automotive Hall of Fame, and the Detroit International Research & Education Foundation.

Jean-Michel Dubernard, MD Surgeon and Professor
l'Université de Lyon

Dr. Dubernard' extraordinary achievements include France's first pancreas transplant in 1976; leader of the team that performed the world's first hand transplant in 1998 and first double hand transplant in 2000, and co-leader of the team that conducted the world's first face transplant in 2005. He has been decorated with the chevalier Ordre National du Merite and the Ordre des Palmes Academiques. Dr. Dubernard has served as deputy mayor of Lyon and as Deputy for Rhone in the French National Assembly.

Michael Duggan Mayor
City of Detroit

Mike Duggan took office as Mayor of Detroit in 2014. During his career he has taken on and un-tangled problems that directly impact the quality of life of Detroiters, including access to health care, public transportation, crime, blight, expanding recreational opportunities in the city, job creation and more. Under his leadership, the city is removing blight at a record pace, has installed more than 35,000 new LED streetlights, secured the purchase of 80 new city buses through federal funds and significantly reduced both police and EMS response times.

In his early career as Deputy Wayne County Executive from 1987 through 2000, he oversaw 14 straight balanced budgets and a fully funded pension system, led the effort to bring the Detroit Lions back downtown, co-chaired the construction of Comerica Park and Ford Field, and negotiated the deal with the Clinton Administration that led to the const- ruction of Metro Airport's spectacular midfield terminal. During this time he also stepped in to run the SMART bus system, which was facing the threat of shutting down. In three years, he turned around the organization's finances and partnered with unions to improve reliability, expand service in Detroit, and increase ridership.

As Wayne County Prosecutor from 2001–2003, Duggan led efforts to reduce gun crime and to address the problem of vacant homes across Detroit by seizing 1,000 abandoned homes and selling them to new owners who fixed them up and got them reoccupied. Before running for Mayor, he again partnered with workers and unions to lead the Detroit Medical Center out of near bankruptcy and back to profitability in his first year (2004). Today, the DMC is undergoing $850 million in new construction as part of a deal Duggan negotiated as CEO.

David Ellis * President
Health Futures Management Corp.

David Ellis is a health futures writer, consultant, and publisher. After a career in intelligence in the Far East and Europe he pursued a career in futuring that led to his appointment as a regular columnist for *Hospitals & Health Networks Daily*, an online publication of the American Hospital Association, and to his appointment as futurist at the Detroit Medical Center under Mike Duggan. Ellis now runs a consultancy and book publishing house from Hawaii but maintains an active relationship with Detroit as executive director of the Detroit International Research and Education Foundation. Besides *Technology and The Future of Health Care*, which won the 2000 HIMSS Book of the Year award, Ellis also wrote *Deus ex Machina sapiens,* a book about the emergence of intelligent machines.

Shakir Hussein, MD Surgical Director and Clinical Chief
Renal Transplant Program
Wayne State University School of Medicine

Dr. Hussein is an attending physician at the Detroit Medical Center, specializing in transplant surgery for both adult and pediatric patients. Following medical school in Sudan and residency at the Cleveland Clinic, Dr. Hussein was awarded fellowships in multi-organ transplant (Columbia University Medical Center, New York), liver transplant and hepatic biliary surgery (ASAN Medical Center, Seoul, Korea), and intestine and multivisceral transplant (University of Pittsburgh Medical Center). He has been a part of the incredible advances made in the science of transplant surgery made in the past several years and conducts research that continues to explore ways to perform less invasive surgery, which is key to helping patients recover quickly.

Mary Kramer *Publisher, Crain's Detroit Business*

Mary Kramer is a seasoned expert with more than 25 years of reporting and management experience. She joined *Crain's Detroit Business* in 1989, and in 1990 was named Associate Publisher. In May 1994, Kramer was named a Vice President of Crain Communications Inc, and in May 2005 she was named Publisher, responsible for sales, circulation, and editorial operations of *Crain's Detroit Business.* In 2012, she was named Group Publisher at Crain Communications, supervising *Crain's Cleveland Business* in addition to Detroit. Today, she is active in many Detroit-area business and civic organizations, including several that support at-risk girls

and education. She is a trustee of both the Skillman Foundation in Detroit and Grand Valley State University (GVSU) in the Grand Rapids area. She was also the first woman to be elected president of the historic Detroit Athletic Club.

Antonia C. Novello, MD United States Surgeon General (1990–1993)

Dr. Novello was appointed Surgeon General by the first President Bush in 1990. She was the first woman and the first Hispanic to hold the position. During her tenure she focused on the health of women, children and minorities, as well as on underage drinking, smoking, and AIDS. She played an important role in launching the Healthy Children Ready to Learn Initiative. Dr. Novello was actively involved in working with other organizations to promote immunization of children and childhood injury prevention efforts. She spoke out often and forcefully about illegal underage drinking, and called upon the Health and Human Services Inspector General to issue a series of eight reports on the subject. Novello also worked to discourage illegal tobacco use by young people, and repeatedly criticized the tobacco industry for appealing to the youth market through the use of cartoon characters such as "Joe Camel." She next served as the United Nations Children's Fund (UNICEF) Special Representative for Health and Nutrition from 1993 to 1996. In 1996, she became Visiting Professor of Health Policy and Management at the Johns Hopkins School of Hygiene and Public Health. Dr. Novello became Commissioner of Health for the State of New York in 1999.

Orlando T. Padilla * President & CEO
Padilla Networks LLC

Orlando Padilla provides global public policy, strategic planning and issues management expertise on domestic and international business topics to Fortune 500 clients and new business ventures. He has served on the boards of 18 non-profit organizations and as Senior Advisor to Board members and officers representing a portfolio potential of 70 Fortune 500/1000 companies in 15 industries. Prior to retirement from a 34 year global career at General Motors, Mr. Padilla's last assignment was Global Senior Director, Public Policy, Corporate & Government Relations with expanded responsibilities for the General Motors Public Policy Center at General Motors headquarters in Detroit.

Padilla was named by Hispanic Business Magazine for several years as one of the most influential Hispanics and listed on the Corporate Elite – Top 100 Hispanic Executives and is a founding member of the Hispanic Association on Corporate Responsibility, Corporate Executives Forum.

Keith B. Pitts Vice Chairman
Tenet Health

Before joining Tenet Health to lead its partnership and corporate development strategies, including acquisitions and joint ventures, Mr. Pitts was vice chairman of Vanguard Health until its acquisition by Tenet. Before joining Vanguard, Mr. Pitts was chairman and chief executive officer of Mariner Post-Acute Network and its predecessor, Paragon Health Network, a nursing home management company. He served as executive vice president and chief financial officer for OrNda Health-Corp, prior to its acquisition by Tenet, and, before that, as a consultant to many healthcare organizations, including as a partner in Ernst & Young's healthcare consulting practice. Mr. Pitts is a certified public accountant and holds a bachelor's degree in business administration from the University of Florida. He is a member of the American Institute of Certified Public Accountants and the Florida Institute of Certified Public Accountants.

J. Edson Pontes, MD * Director
Chateau Chantal

Dr. Pontes is a thought leader in urologic oncology and one of the pioneers in the diagnosis and treatment of prostate cancer. He retired from the Chairmanship of the Department of Urology at Wayne State School of Medicine in 2012 but continues to practice in his specialty, oncological surgery, at the Karmanos Cancer Institute, the Detroit Medical Center, and the John A. Dingell Veterans' Hospital. He was formerly Head of International Services for the Detroit Medical Center, where among other duties he oversaw the operation of an international guest hotel and services to visiting international patients and physicians, and before that he served as director of urologic oncology at both the Cleveland Clinic and Roswell Park Cancer Centers. He is internationally recognized as a specialist in genitourinary (bladder, kidney, prostate, testicular) oncology and surgery, and treated French President Francois Mitterand in the 1990s.

Braden Robison Chief Operations Officer
Seraph Biosciences, Inc.

With over 15 years of experience in medical devices, Braden has launched more than one hundred products through the FDA regulated process. As Senior Director of Business Development and Strategy for Stryker Corp., he successfully led $235M worth of transactions and started 2 different

divisions for the company. Braden also serves as a Mentor-in-Residence at the University of Michigan's Tech Transfer and is a Principal for 1021 Partners aimed at helping early stage companies build and grow their businesses.

David Selby Chief Operating Officer
Xenith

David Selby oversees all aspects of Xenith operations including those of its Detroit factory, which produces NFL-approved helmets for schools and professional football teams. Xenith is a member of the Quicken Loans family of companies.

Pamela Shaheen, DrPH Adjunct Professor
School of Public Health, University of Michigan

Dr. Shaheen is the Founding director of The Delta Collaborative, which advises and coaches individuals and organizations interested in successfully managing change to maximize performance. Formerly, Dr. Shaheen served as a Senior Fellow with the Michigan Public Health Institute, where she was engaged in researching health issues and identifying policy options to address them, and as Health and Human Services Policy Advisor to former Michigan Governor Jennifer Granholm. Dr. Shaheen has been a consultant to several national foundations, held administrative positions within the Michigan's Department of Public Health, and served as the Senior Health Policy Advisor to the Speaker of the House in Michigan's House of Representatives.

Paul N. Shaheen Founder & former Executive Director
Michigan Council for Maternal & Child Health

Paul Shaheen founded and led the Michigan Council for Maternal and Child Health, where he successfully lobbied the Michigan legislature to protect the health and wellbeing of mothers and children for over 20 years. He is now a University–Community Senior Fellow at the Michigan State University Office of Outreach and Engagement. In early life served in the Peace Corps in Peru, acquiring passable Spanish in the process.

Charles J. Shanley, MD Founder & Chairman
Seraph Biosciences, Inc.

Dr. Shanley is a vascular surgeon and critical care specialist. An accomplished academic surgeon, he holds professorships at Wayne State University School of Medicine and Oakland University–William Beaumont School of Medicine. Dr. Shanley's research has been funded by the U.S. Army Telemedicine and Advanced Technology Research Center, the Michigan Economic Development Corporation, and the National Institutes of Health. He serves on the Health Care Patient Safety and Quality Study Section of the Agency for Health Care Research and Quality and was appointed to the Circulatory Devices Advisory Panel at the Food and Drug Adninistration. In 2011, he co-founded Medical Engineering Partners, a solutions-centered advanced biomedical engineering and prototyping firm specializing in smart sensor innovation. In 2014, Medical Engineering Partners launched Seraph Biosciences, Inc. to commercialize Seraspec™, the world's first portable, reagentless Raman spectroscopic platform for real-time pathogen identification at the point of care.

Jack D. Sobel, MD Dean
Wayne State University School of Medicine

A graduate of the University of the Witwatersrand in Johannesburg, South Africa, Dr. Sobel is one of the world's foremost authorities on bacterial vaginosis. He has served as a consultant for the U.S. Centers for Disease Control and Prevention's special committee for recommending guidelines for the treatment of sexually transmitted diseases, and as president of the Michigan Infectious Diseases Society. He is a member of the National State President's Committee and the Infectious Diseases Society of America's Practice Guidelines Committee. He is chair of the Division of Research in the internal medicine department at WSU, and a professor of Immunology and Microbiology, and Obstetrics and Gynecology.

Anthony J. Tedeschi, MD Chief Executive Officer
Detroit Medical Center

Before joining the Detroit Medical Center as CEO in 2017, Dr. Tedeschi served as CEO of Tenet Health's four-hospital Chicago Market as well as CEO at Chicago-based Weiss Memorial Hospital. Prior to joining Tenet, he served as COO of Cook County Health & Hospitals System in Chicago. He earned his medical degree from the University of Illinois at Chicago, his

MBA from Chicago-based Northwestern University and a master's degree in public health from the Medical College of Wisconsin in Milwaukee.

Mark Trexler Founder & Operations Advisor
Seraph Biosciences, Inc.

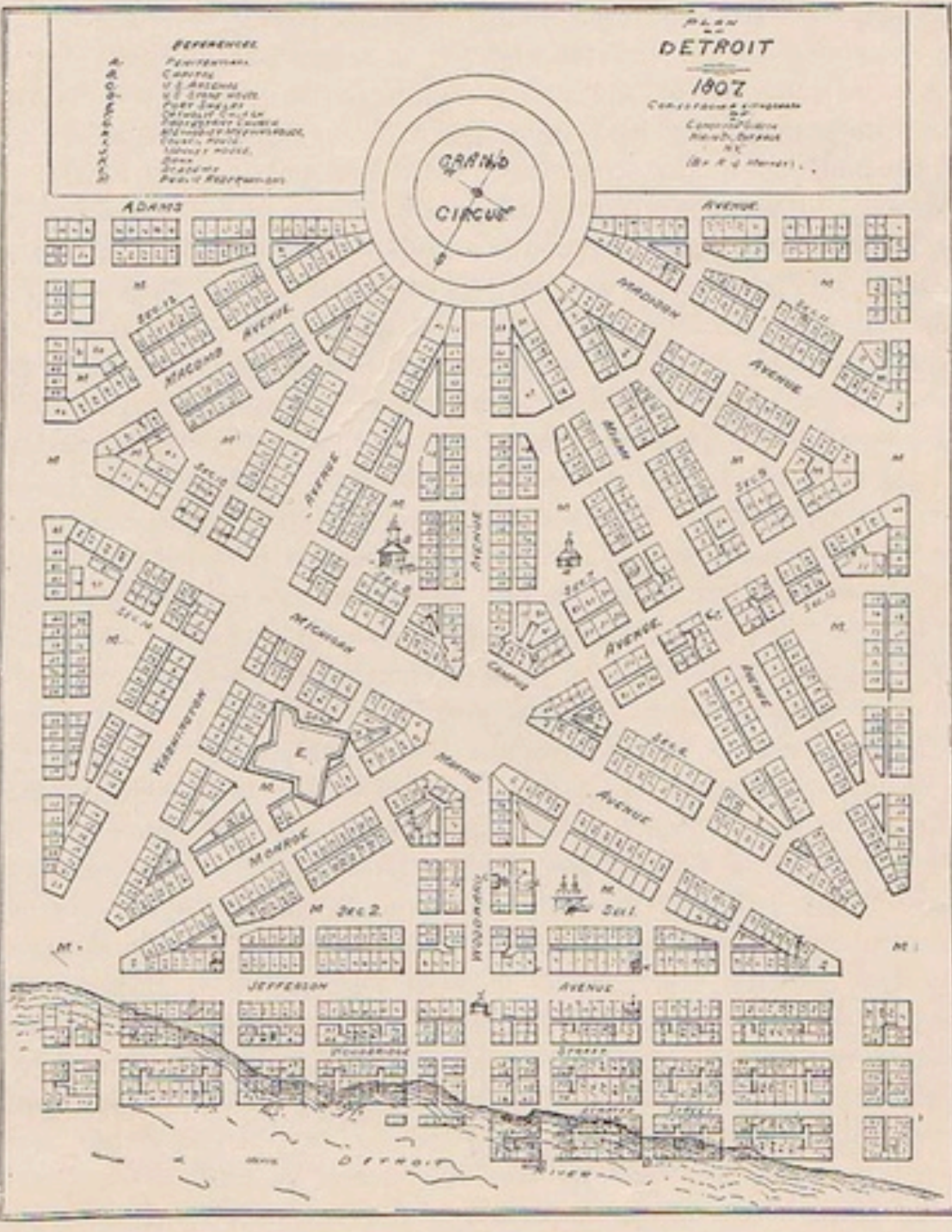
Mr. Trexler is a founding partner in Medical Engineering Partners and helps manage the day to day operations, including the strategic and operational planning activities required to help launch the company. Mr. Trexler earned his BS degree in Chemical Engineering and an MBA with a concentration in finance. Mr. Trexler started his entrepreneurial career over 20 years ago by founding Technical Enviro Services, Inc., of which he is CEO and owner. Mr Trexler has participated in the start-up of several other successful consulting/service companies.

Donald W. Weaver, MD * Chairman
Michael & Marian Ilitch Dept. of Surgery

Donald Weaver, MD, is Chair of the Michael & Marian Ilitch Department of Surgery at Wayne State University School of Medicine and Surgeon-in-Chief for the Detroit Medical Center. He is also an active clinical surgeon with expertise in surgical oncology and minimally invasive surgery. He travels extensively abroad, particularly India, the Middle East, and Brazil for work-shops, lectures and activities of charity. Dr. Weaver is president of the Detroit International Research & Education Foundation.

Chunwu Wu, PhD Chief Scientist
Stryker IMT

Dr. Wu has served as Stryker's chief scientist for 20 years. He is an expert in computer-assisted surgery, surgical navigation and robotic surgery, and invented the most accurate surgical tracking system in the world—the Stryker Navigation System II camera—as well as the most accurate magnetic localizer in the world and a combined optical/non-optical navigation system that eliminates time lag in robotic surgical tracking. Before joining Stryker, Dr Wu developed a prototype three-dimensional reconstruction package for Positron corporation's positron emission tomography (PET) systems. He is the holder or co-holder of numerous patents.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