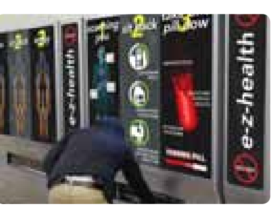
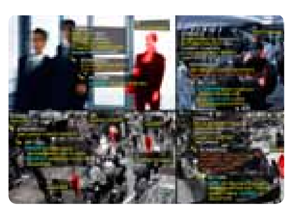
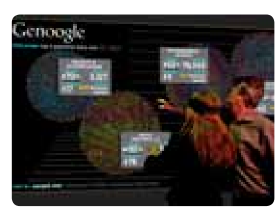
Information Ecosystems of Well-being:

ARTIFACTS

2032







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About ...

Health Horizons Program

The Health Horizons Program offers its clients a deep understanding of the global health economy and the social forces that will shape health and health care in the next three to ten years. We identify and evaluate emerging trends, discontinuities, and innovations in consumer strategy and social media; health and medical technologies; health care delivery systems; and food, nutrition, and sustainability. Our forecasting process helps organizations work with foresights to develop insights that lead to specific strategic actions they can use to better position themselves in the marketplace.

Institute for the Future

The Institute for the Future is an independent, nonprofit strategic research group celebrating more than 40 years of forecasting experience. The core of our work is identifying emerging trends and discontinuities that will transform global society and the global marketplace. We provide our members with insights into business strategy, design process, innovation, and social dilemmas. Our research spans a broad territory of deeply transformative trends, from health and health care to technology, the workplace, and human identity. The Institute for the Future is located in Palo Alto, California.

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Introduction:
Welcome to 2032

Today we're on the verge of a revolution in health information. After a decade of generating unprecedented amounts of data, we're just coming to understand the promise it holds for our health and well-being. By 2022, we'll see innovators creating tools to harness the flow of data and make it actionable. But we must take an even longer view. Many of the technologies and trends in play in 2022 will not reach their full potential until a decade later. And to truly understand the transformation that's underway, we have to look to a time when that transformation is more complete. By 2032, the dust will have settled, consensuses will have been reached, and new health information practices and services will have become mainstream. Information ecosystems will be in a state of balance.

This report is an introduction to this distant world in which health and well-being have successfully reorganized around new flows of information. Understanding a world this different, this far in the future, and developing strategies to thrive in it can be difficult. We've prepared this report to immerse you in the world of 2032 so you can start planning now to take an active role as information ecosystems of health and well-being come into balance.

Part 1:
Technological Transformations Reshaping the Pursuit of Well-being

In this section, we ground our vision of 2032 by explaining how the technological developments of the next two decades will drive five major shifts that will create this radically different world. This section can also be used as a framework for understanding these changes as they happen and for developing your own strategies for leveraging the shifts to prepare for the future.

Part 2:
Health and Well-being Artifacts from 2032

This section describes five health and well-being artifacts from 2032—products, services, or experiences that might emerge if today's forecasts about the future materialize. Each is presented as an image with accompanying text telling how people interact with it. We also explain the technological advances that have made each artifact possible.

Part 3:
Your Place in Health Information Ecosystems in 2032

We conclude this report with a short guide to using the artifacts to help you develop your own strategies for making health information actionable in the future.

Part 1: Technological Transformations Reshaping the Pursuit of Well-being

Advances in automation, ubiquitous programming, blended digital and physical realities, and pervasive simulations will accelerate as different technologies evolve over time. These combined advances will create five key directions of technological transformation that will shape our pursuit of health and well-being.

1. THE ROBOTS ARE COMING

npr.org/blogs/alltechconsidered/2012/02/17/147006012/when-the-car-is-the-driver

GOOGLE'S SELF-DRIVING CARS
The "robot chauffeur" is already a reality and the policy infrastructure is adapting to get on the road.

In early 2012, journalist David Brancaccio ventured out on a cross-country round trip from New Jersey to California, and completed it without making contact with a single human being. And he did it with the help of robots. While not exactly the humanoid robots of science fiction fame, the systems he used at self-service gas stations, ATMs, and self-checkout hotels grocery stores are robotic.

Automated machines have been a big part of our society since the 1950s, when factory workers met the first industrial robots. By 2032, they'll be vastly more powerful and pervasive. In some areas, the machines will become our collaborators, augmenting our own skills and abilities. In other domains, the robots will replace humans, freeing us up to do the things we're good at and actually enjoy—or taking livelihood away from people who did those things professionally. Having automated systems that literally and figuratively guide us as we move through life will transform how we work, shop, parent, connect, and take care of ourselves and each other.

Take, for instance, the self-driving car. Once a sci-fi dream, the self-driving car is here today—and the policy infrastructure is adapting as well, with Nevada having approved the creation of a licensing system for such cars, and Hawaii, Florida, California, and Oklahoma soon to follow. A world where everyone has his or her own personal (robot) chauffeur is a good way to think about the oncoming robot revolution and its implications for health and well-being.

2. WHEN EVERYTHING IS PROGRAMMABLE

The word *robotic* currently has certain connotations. It usually implies rigid, linear, and unresponsive. But the robotic systems of 2032 will be none of these things. These smart systems will be highly customizable—both aware of and responsive to our individual preferences, needs, and physiological states.

People are already using geolocation apps like Geoloqi to program their smart phones to automatically send them alerts when they arrive at a specific location, or even to make changes to objects in an environment when they come near. Today this is limited to, say, programming our air-conditioning system to start up whenever we get within a half mile of our home, or sending an alert when we happen to be near a public library. By 2032 these capabilities will be much more powerful.

We'll be able to program more than just electronic devices. Programmable matter—physical materials that can take on different shapes and sensations, or release smells or sounds—will allow for physical environments that can be reconfigured to suit the needs of whoever happens to be in them at a given time. And the kinds of inputs they will be able to respond to will change dramatically as well. Currently, most devices can only respond to our location and explicit instructions we issue through voice command and text input. In the future, they will be able to sense information like body temperature, pulse, gesture, and facial expression and combine these data to obtain (and then respond to) a comprehensive understanding of our physical and emotional states.

As more of the world becomes programmable, customizable, and modifiable—and as more people are able to program more of the activities in their daily lives—we will be able to manipulate our built environments and enhance our interactions to build capacities for producing health and well-being.

Programmable matter—physical materials that can take on different shapes and sensations, or release smells or sounds—will allow for physical environments that can be reconfigured.

3. ADDING A DIGITAL LAYER TO OUR DAILY LIVES

The initial promise of the Internet was that it made information place-agnostic. It gave anyone the ability to put information into, or pull information out of, digital space from anywhere at any time. But the advent of mobile Internet and GPS devices has flipped all this on its head. Location-based Internet services now give us information specific to the time and place we occupy at a given moment.

This geographically specific Internet information is a digital layer on top of our physical world. The digital layer includes everything from restaurant reviews that we can access with apps like Yelp! to road condition information that apps like Waze provide us with. It takes abstract, invisible information about a given physical place and makes it visible and accessible.

While today we access this digital layer mostly with our smart phones, in the future we will access and interact with it through an array of different devices, from smart car windshields to smart clothing. And the information won't all be visual. Some of it will be communicated through sound or even touch. For instance, today select Whole Foods locations play audio stories about their produce when customers approach it, and haptic technologies allow us to feel how close we're getting to a certain location. Beyond that, the device with the most potential to blend the physical and digital worlds is augmented reality glasses, which overlay text and other digital information onto our vision as we move through the real world.

With more of the virtual and the physical integrated, the Web will no longer be a separate domain from the physical; rather, it'll be a layer passively streaming onto the world around us. Living in a more blended reality will transform not only how we access information and communicate with others, but also how we make decisions about our health and well-being.

4. EVERYONE AN INNOVATOR

Lightweight innovation taps a distributed set of participants with various levels of expertise and involvement to rapidly prototype new ideas, reducing the risks associated with proof-of-concept experiments.[1] In contrast to traditional R&D groups, which have scaled by growing bigger, lightweight innovation systems scale by quickly engaging more resources in a network to produce a new product or system and then disengaging at a similar speed.

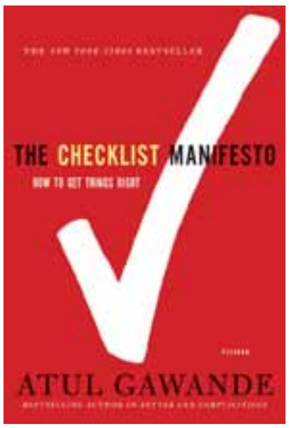
Much as low-cost laser printing jumpstarted the desktop publishing revolution, access to inexpensive tools for micromanufacturing and 3D printing will distribute pieces of larger problems to an array of solvers. In health and health care, lightweight innovation practices will chip away at the capital-intensive, lengthy, and centralized model that has dominated R&D in the pharmaceutical industry for decades.

The falling cost and complexity of biotechnology tools will put them in the hands of everyday people and empower a wave of "garage biotech" innovation. It may unlock roadblocks in life sciences and accelerate drug discovery, potentially bringing life-saving cures to market faster and cheaper.

The falling cost and complexity of biotechnology tools will put them in the hands of everyday people and empower a wave of "garage biotech" innovation.

1. For more on lightweight innovation, see Anthony Townsend's *The Future of Lightweight Innovation: How New Models for Shaping the Web Will Reshape R&D*, Institute for the Future, SR-1259, 2009.

5. ALGORITHMIC FUTURES



An algorithm is, essentially, just a set of rules that can be applied to solve a problem in a step-by-step way. For example, in his 2009 book *The Checklist Manifesto*, Harvard public health professor Atul Gawande makes the case for using a situation-specific checklist, a kind of algorithm, to vastly improve the outcomes of health procedures. And because they rely so heavily on clearly defined rules and measurements, algorithms are the basis of most real-world computational processes.

They're also the basis of predictive systems. Health insurance companies use them, for instance, to assess how risky taking on a potential customer might be. In recent years, great strides have been made in creating predictive algorithms for health. One example: in 2009 researchers developed an algorithm that can anticipate when a person is on the verge of experiencing stress by monitoring his or her typing patterns.

By 2032, both computational processing power and available datasets will have increased dramatically, driving the development of increasingly sophisticated algorithmic processes. This will create a world in which algorithms crunch data to make interventions just in time or, in some cases, ahead of time, vastly improving capacities for public health as well as self-care.

CONCLUSION

These five key directions of technology development will gradually inform how we design information ecosystems for well-being.

1. Advances in automation will incrementally influence the practice of clinical care, and health professionals will benefit from building effective partnerships with smart technologies that leverage both human and robotic strengths.

2. Many of us will have the ability to program more of the conditions of our daily lives in a deliberate effort to enhance our capability to practice positive health behaviors and good self-care.

3. The passive streaming of digital content onto the world around us will influence how we make decisions about our health and well-being.

4. Lightweight manufacturing will expand the sources of medical discovery, as more players will have access to critical tools necessary for conducting research.

5. Finally, algorithmic processes will enable just-in-time interventions and new capabilities for delivering public health services.

Part 2:
Health and Well-being Artifacts from 2032

In the view of archeology, ancient artifacts like stone tools, pottery, and items of personal adornment offer insights into the daily lives of people in the past. The Institute for the Future designs and creates artifacts from the future—products, services, or experiences that might emerge if today's forecasts about the future materialize. These artifacts offer insights into future humans' daily lives. They are intended not to advocate a certain future or promote the development of any particular product or service but instead to give you an immersive, on-the-ground look at future change.

This section describes five artifacts from 2032. Each is presented as an image with accompanying text telling how people interact with it. We also explain the technological advances that have made each artifact possible. The artifacts represent these key areas of health and well-being:

- self-care
- health decision making
- clinical care
- public health
- medical discovery

Self-care in 2032:
Making Health Effortless

In 2012, tech-enabled self-care practices require that individuals are highly engaged in their health and proactive in introducing technology into their practices. By 2032, tech-enabled self-care will use data to reduce the level of engagement, motivation, or attention required of the individual to almost nothing.

E-Z-HEALTH

Subscribers to the e-z-health system walk up to an e-z-health kiosk once a day to receive a body scan. The kiosk uses their data to make changes to the person's environment and makes some health decisions, like food choices, for the subscriber, then prints a custom pill to suit their individual needs.

E-Z-HEALTH

Erica became comfortable with not knowing exactly what e-z-health was doing; now she just sits back, relaxes, and enjoys it.

Like most people, Erica knew how to stay healthy—lots of exercise, sleep, time with friends and family, and eat fresh, unprocessed food. What she didn't know, though, was how to find the time and motivation to do those things with any regularity. In fact, since turning 35, she had been slowly adding weight and was carrying more stress from her job, her struggling relationship, and her aging parents' declining health. She knew what she needed to do but couldn't seem to get it together. She loved soccer, so she tried to participate in pick-up games and in other social forms of exercise, but with her work schedule she never really had the time or energy.

Erica's friends, though, had a solution they swore by: e-z-health, a program that "makes health effortless" by making decisions for users and making subtle changes to their environments. Erica was skeptical. For one thing, the program collected a lot of data about its users—something it needed to do to be effective. Although the company offered a steep discount to users who gave e-z-health ownership of their data, it wasn't completely transparent about what it did with the data. It advertised that it donated a portion of its data to public health agencies, which Erica thought was great, but it also sold a lot of the data to advertisers and corporations whose values Erica was not aligned with. Plus, she wasn't totally comfortable with something else making decisions for her. She felt like it reflected poorly on her will power. But after seeing the results her friends were getting and being offered financial incentives by her insurance company and employer, she decided to give it a go.

Now, every day on the way to her desk, Erica stops by the e-z-health vending machine in the break room. She plugs in her mobile device and stands in front of the image scanner so that it can get a read on her health status. She waits for 90 seconds while it prints a customized tablet, containing nutrients and/or pharmaceuticals, and it makes adjustments to Erica's environment. Some days, it adjusts the lighting in her home or office, and it often pumps different smells into her car to program her mood. Once it even changed the incline of the steps in her home. And most days, it orders food from the company cafeteria for her.

For the first several weeks, Erica reviewed e-z's decisions carefully, at times manually overriding them. But this became a chore and she was steadily losing weight, so she figured e-z was doing something right. Gradually, Erica became comfortable with not knowing exactly what e-z-health was doing; now she just sits back, relaxes, and enjoys it.

Self-care in 2032:
Making Health
Effortless

THE CHANGING TECHNOLOGICAL LANDSCAPE OF SELF-CARE

In 2032, the primary tasks of self-care will remain the same: collecting data, analyzing it to glean insights, and taking action in response to those insights. The biggest difference is that in two decades a number of technological advances will allow us to do these tasks more accurately and without nearly the level of engagement required today. Self-care tools and services will work in concert to help us make choices and adjustments that align with our health goals.

Self-care tools and services will work in concert to help us make choices and adjustments that align with our health goals.

Many tech enthusiasts already leverage **abundant mobile computing** (smart phones) to gather health information, such as food intake and exercise, and use **cloud computing** to store the data remotely and access it from anywhere. But our ability to track this kind of health data will expand greatly as various smart, **networked sensors and computing chips** become available to the consumer. **Biosensors** embedded in our bodies and environments will automatically track things like air quality, noise, temperature, blood sugar, movement, and emotion.

Our ability to analyze this data will increase greatly as well. Whereas today much of the data we have was created for a specific purpose and is not usable across platforms, in the future shared standards and frameworks will allow **data fusion** tools to cross-analyze data from many different sources. For instance, biosensor data will be combined with social media streams along with population and public health data. This will allow systems like e-z-health to use powerful **algorithms** to create a comprehensive picture of a user's well-being at a given moment.

Perhaps the biggest advances, though, will be in systems that respond automatically to our health state. We will be able to **program** many different devices in our environment, including home heating and lighting systems, office and car aromatherapy systems, food and medicine printers, and even body-implant pharmaceutical dispensers. These **actuators**, or mediums that perform actions or make adjustments, will respond to information provided by sensors and physically alter our environments in the name of preventive health.

Health Decision Making in 2032: Multisensory Information Flows

In 2012, the information we need in order to make decisions about health and well-being is viewed on screens—televisions, computers, tablets, and phones (to access Web sites, blogs, and social networking sites)—or reading magazines and newspaper articles, in addition to talking with doctors, nutritionists, trainers, coaches, and friends and family. In 2032, information for health decision making will be communicated through multisensory modalities.

THE HEALTHCART

The HealthCart is an open-source cart that uses the shopper's personal data to offer decision support information, in a subtle, non-distracting way, by engaging all the senses.

THE HEALTHCART

A trip to most grocery stores brought with it a flurry of different alerts from his own devices and from displays in the store. And it had worked—for a while. But within about a year Dae had begun to tune it all out, and he often found himself in the ice cream aisle despite his devices' protestations.

When Dae Kim first set foot in HealthMart, he felt like he had gone back in time. The store was promoting itself as cutting-edge, but it seemed pretty old-fashioned to him. Dae had signed up for just about any nudge-based health app he could find; he put his faith in them to steer him to the right decisions. A trip to most grocery stores brought with it a flurry of different alerts from his own devices and from displays in the store. And it had worked—for a while. But within about a year Dae had begun to tune it all out, and he often found himself in the ice cream aisle despite his devices' protestations.

HealthMart wasn't activating any of his apps. In fact, it didn't even have many displays, just comparatively plain-looking aisles stocked with food and goods. What it *did* have was smart HealthCarts, a crowd-created open-source shopping cart, and the moment Dae grasped the handle he began to see what the big deal was.

> "Dae, do I have permission to sync with your other devices?" the cart asked. He granted it permission. After a moment, it spoke again.

> "I'm going to customize your shopping experience to help you make decisions that are consistent with your values and preferences, based on your biomimetric and financial data, your communications and shopping history, your . . . " It went on so long that Dae tuned it out for a moment.

Dae decided to take the HealthCart tutorial and had a blast walking around the store seeing what it could do. When he walked through the produce aisle, the cart emitted enticing aromas. When he passed by the cookies, it started making a subtle but noticeably unpleasant buzzing sensation on his hands. Not only was the experience fun and novel, it was a lot less stressful than his typical shopping experience, because nothing the cart did competed with the messages Dae was receiving on his personal devices.

> "I'm becoming heavier because you're adding processed food," the cart told him when he put a frozen pizza into it. "You may notice it becomes harder to push me."

He opted then to turn off the tutorial and just let the cart make adjustments for him. As subtle as it was, he always knew when the cart was altering its smell and feel. Whereas he had learned to ignore his various notifications, the cart communicated with him on a frequency he had not yet learned to tune out. "This is where I'll be coming to shop," he thought. The HealthCart gave good advice, but more than that, it made sure he *considered* that advice.

Health Decision Making in 2032: Multisensory Information Flows

THE CHANGING TECHNOLOGICAL LANDSCAPE OF **HEALTH DECISIONS**

The smart cart represents two aids to health decision making that developments in technology will enable over the long term—the use of multisensory signals to cut through information overload and the use of customization technology to tailor environments to support our health.

Today, with information being produced and published so rapidly, it's difficult to sort through the deluge of content and find meaning. In response, the fields of **information architecture**, **information design**, and **information management** are growing, with individuals and organizations searching for better ways to structure, process, and filter content. **Web aggregators** and **Web crawlers** methodically and automatically scan the Web for important content to deliver to individuals. **Algorithm-based digital information filtering and prioritization processes** aim to eliminate unnecessary information by ranking content and bringing only the most relevant to a person's attention.

But by 2032, the aim of cutting-edge technology will no longer be to draw attention to particular content in an already overcrowded information environment. Filtering and prioritization of the massive amount of information available will remain important, but new ways to communicate information will evolve to leverage all of our different sensory systems. **Multisensory research** will reveal how the brain combines and synthesizes information from multiple senses, and **programmable matter** will allow physical materials around us to take on different shapes and sensations, or release smells or sounds, to capture our attention. In high-information environments where competing displays overwhelm our ability to process content visually, more interfaces will make information felt, heard, smelled, or tasted. Actionable information will seep into our brains through multiple sensory channels.

The other aspect of the smart cart is that it interacts with the environment. Today, we see experiments in creating built environments that encourage healthy decisions. The cafeteria at Google's corporate headquarters, for instance, locates health food items in places where they are easy to see and reach, and where they look most attractive, and does the opposite for unhealthy items. Beyond that, **the technologies to add a digital layer to our lives** will allow us to change our environments in ways that support individual notions of health and well-being as opposed to mainstream standards.

In high-information environments where competing displays overwhelm our ability to process content visually, more interfaces will make information felt, heard, smelled, or tasted.

Clinical Care in 2032: New Professions for Twenty-first-century Medicine

In 2012, combinatorial research approaches are beginning to blend biological sciences, materials science, robotic engineering, and nanotechnology to create new therapies and medical interventions. By 2032, new medical professions will have entered the global health economy to deliver twenty-first-century clinical care that integrates nanostructures, artificial intelligence, smart implants and prosthetics, and robotic surgery.

GLOBAL HEALTH HEROES

New professions: Emerging technologies reshape existing medical professions—in countries where policy decisions around education and regulation allow them to.

GLOBAL HEALTH HEROES

Dr. Karat had had the good fortune to be part of India's medical revolution. The country's leaders had proactively pursued policies that encouraged mainstream clinics to adopt radical new practices and procedures based on cutting-edge advances in science and technology.

It felt a little strange seeing the word *Hero* in large letters near her face, but appearing on a magazine cover was certainly flattering for Dr. Shri Karat. *Science* magazine had named her a "health hero" for being one of the first practicing biomechatronic engineers, a profession that combined skills in biology, mechanics, and electronics to fit patients with smart orthotics and prosthetics that could precisely emulate human movement.

The other health heroes featured in the magazine were in very recently minted professions as well. The epigenetic oncologist focused on anticipating and detecting disease upstream and then treating leukemia and lymphomas by treating gene expression. The nanobio pharmacist delivered biopharmaceuticals and therapies through nanobiotechnology applications that were routinely embedded in human bodies. The enterotype diagnostician used metagenomics to reclassify people based on their microbiomes' response to diet or drugs. Empathetic robotic technicians helped psychologists and other specialists treat behavioral and social health conditions through applying their training in biology, psychology, computer science, and biomedical engineering.

The robot on the cover was a caregiving model robot, but robots had become common in surgery, cardiology, gynecology, and urology as well. In fact, robot-assisted surgeries had overtaken physician-only surgeries in major Indian hospitals in 2025, and as a result the clinical setting had been overhauled to reflect AI-enabled interventions. And that's why Dr. Karat, in all honesty, didn't feel like she had had any more agency in becoming a "health hero" than the robot had.

I got lucky, she thought. I went to med school in the right place at the right time. Dr. Karat had had the good fortune to be part of India's medical revolution. The country's leaders had proactively pursued policies that encouraged mainstream clinics to adopt radical new practices and procedures based on cutting-edge advances in science and technology. Public university curricula had been built around these advances as well, and they were preparing India's medical students for careers in a whole host of new fields. Had she gone to school a couple of years earlier, there would have been no classes in biomechatronic engineering.

She knew others who hadn't had her good fortune. Her brother, Prakash, who had finished training as a surgeon just five years ago, had found no hospitals in India, or anywhere else in the region, willing to take on new surgeons with no robotics experience. Prakash had returned to school, but there was another option he was considering, one that would be hard on Dr. Karat. Prakash could go to the United States, where oversight and policy-led decisions around licensing of new professions and reimbursement for new procedures had lagged, and where limited third-party payment was making robot-assisted surgery cost-prohibitive for most.

THE CHANGING TECHNOLOGICAL LANDSCAPE OF CLINICAL CARE

The health professions depicted in the “Health Heroes” magazine cover story are based on research that is under way today thanks to high-resolution simulations and modeling, combined with advances in **nanotechnology**, which will uncover new capabilities to diagnose and treat disease at a molecular and atomic scale. For instance, today DNA-based computers are currently being developed in research labs. These tiny implantable computers the size of a blood cell would allow scientists to program inside cells to either cure or kill the sick cells and leave the others intact.

The health professions depicted in the “Health Heroes” magazine cover story are based on research that is under way today.

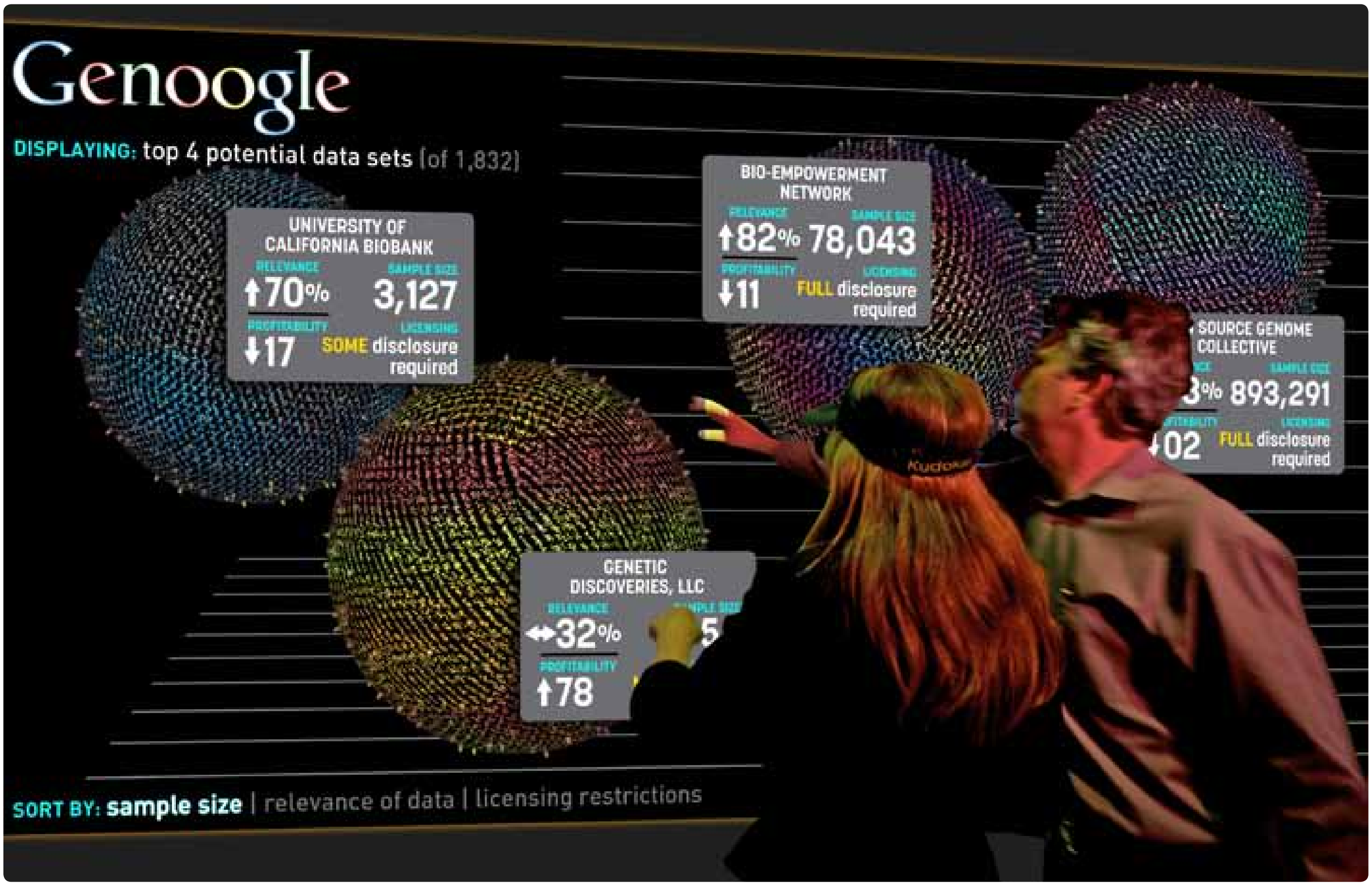
In fact, the categories of minimally or noninvasive surgery will have expanded to include almost all types of surgeries, leaving many to ask if it is still accurate to call the medical procedure surgery when no knife is involved. Surgery is likely to be revolutionized by robots. By 2032, rarely will human hands touch the body of the person undergoing surgery, and **robotic surgeries** will increasingly become the standard of care in markets in which the regulatory environment has not stalled the practice.

Over the coming decades, the interdisciplinary field of **biomechatronics**, which integrates biology, mechanics, and electronics, will have spurred significant advancements in designing and implementing **smart prosthetics**. Limbs and organs will be replaced by intelligent devices that depend on **biosensors** to relay information to **actuators**, or artificial muscles, to mimic human movement so the wearer can control limbs by thinking about the motion. In addition, **neuroprosthetics**, operating like implanted computer chips, will enhance cognitive functions, improving focus, alertness, or memory.

The ability to sense and convey people’s emotional and physiological states will increase, allowing clinicians and health providers to discern our mental health state through our body posture, spatial and kinesthetic movement, facial expressions, and speech modulations. **Gestural computing**, **sensing palettes**, and **haptic technologies** will improve not only how care is delivered face to face but also the experience of remote care, as providers will have more tools to ensure that they are delivering virtual care effectively and empathetically.

Medical Discovery in 2032: Closing the Science-to-Service Gap

In 2012, biomedical knowledge is exploding, but without a widespread improved ability to capture and translate that knowledge into saving human lives. In 2032, the focus will have turned to applying scientific discoveries to improve health outcomes.



GENOOGLE

Researchers at Kankudo Pharmaceuticals use Genoogle to browse potential data sets to use for medicine development. The interface lets them sort by many metrics, including how relevant the data is to their work, how large the sample size is, and what kinds of licensing restrictions the different data sets have.

GENOOGLE

The best data came from organized collectives of biocitizens, or individuals with a shared passion to uncover treatments and cures for specific diseases and conditions.

Choosing data to work with was easily Jake's least favorite part of the job. Sure, the browsing interfaces are a lot of fun, he thought to himself as he stood in the data room of Kankudo browsing Genoogle search results, moving huge clouds of data with his hands. But choosing was always fundamentally an emotionally fraught process. The best data came from open-source collectives of individuals sharing data freely, but any medicines and therapies Kankudo might derive from such data would be largely unpatentable, and the organization still had to make a buck.

The amount of data available to researchers had expanded exponentially in the last couple decades. As the price of genetic testing had plummeted, millions of individuals across the globe had begun getting tested and now owned the results of their own genetic tests. Once they had the results, many contributed their data to research studies, despite lingering questions about the clinical utility of direct-to-consumer genetic testing. And most people with a health condition—following a diagnosis, or in search of one—regularly contributed personal health data to open, crowdsourced research hubs in an effort to expedite progress.

Given the popularity of sharing health data, scientists had a wide range of third-party data vendors from which to choose. The best vendors for companies like Kankudo were private ventures that had purchased data from individuals, organized it into data sets, and were selling it to labs and scientists for private use. Those vendors had no expectation that the purchaser would share findings or any future revenue that might result from using the purchased data, but the data they offered was only somewhat useful. Kankudo could get better data from academic labs that shared data openly, but these labs expected that breakthroughs that came from their data would be shared only with them, and that any revenue that came from commercialization of a new therapy or compound would be distributed among the participating universities.

The best data came from organized collectives of biocitizens, or individuals with a shared passion to uncover treatments and cures for specific diseases and conditions. Large, self-funded, double-blind, placebo-controlled, multi-site studies were routinely under way, often led by curious young scientists and advised by a number of retired scientists with a lifetime of experience running clinical trials for pharmaceutical companies, academic institutions, or government agencies. And these collectives made their data available for free—but with the expectation that the results of research using the data would be shared publicly.

Frustratingly, this kind of data was poison for organizations like Jake's. But as a publicly traded company, Kandudo was legally obligated to try to make its shareholders the most money possible. He sighed and purchased a set from Genetic Disorders LLC and chose to focus on making the most of it.

Medical Discovery in 2032: Closing the Science-to-Service Gap

THE CHANGING TECHNOLOGICAL LANDSCAPE OF MEDICAL DISCOVERY

Today, scientific discovery and medical research have benefitted greatly from a finer, more precise understanding of human biology. **Big data storage** and **cloud computing** are bolstering efforts in **translational scientific research**, blending findings in the biological sciences with neuroscience, psychology and behavioral economics, and environmental sciences to consider a wider range of interacting determinants of our health and well-being. Still, turning the findings from the expansive amount of research under way into standard medical practice in any meaningful way remains a challenge.

Most of the scientific and medical research in 2012 is taking place in academic or private labs, with findings shared largely at the discretion of the lab. The closed and siloed approach to research creates structural challenges to sharing findings quickly and casually, making it difficult for disparate labs to work collaboratively or even build on each other's successes and failures. This lack of open, participatory research contributes to the seventeen-year science-to-service gap between the time of a new discovery in the lab and its widespread application in clinical settings.

By 2032, however, the sources for funding and conducting research will have expanded markedly. **Online crowd funding platforms**, initially developed for individuals to fund consumer products and artistic endeavors at their earliest stages, will be active conduits for funding medical research. In 2012, a few researchers and entrepreneurs are experimenting with crowdsourcing data and crowd funding research, but in twenty years, **open and automated Web platforms** where individuals can share data and researchers can post ideas for studies will be commonplace and will account for an increasing portion of medical research. Traditional organizations will not see the majority of benefits from this kind of open innovation, though, as medicines and therapies derived from participatory research will largely be unpatentable.

In addition to new funding models and data sources for medical research, by 2032 commercially available manufacturing tools will expand access to equipment and technologies traditionally found only in highly funded private and academic laboratories. Affordable **3D printers** that can fabricate, or "print," drugs will open the door for more individuals to experiment with the potentially controversial practice of designing personal drugs, and for more therapeutic research to be conducted outside of formal laboratories.

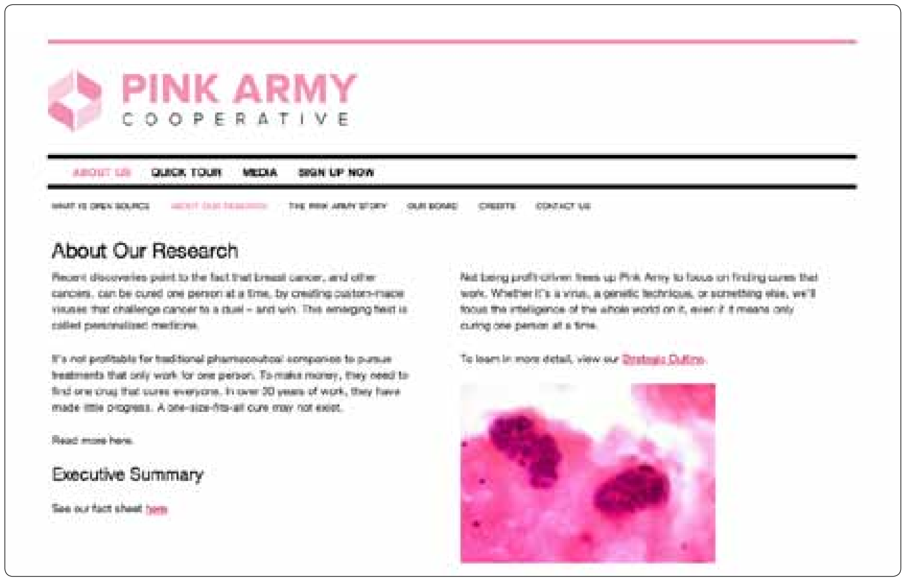
Source: microryza.com/discover

MICRORYZA
This crowdfunding site was founded by scientists who had become frustrated with current funding models.

MEDICAL DISCOVERY (continued)

PINK ARMY COOPERATIVE

The Pink Army is an open source cooperative that aims to develop drugs customized to an individual's cancer.



Source: http://pinkarmy.org

Finally, a more participatory, distributed, and translational approach to medical research will accelerate the pace of **tailored medicine**, or linking treatments to an individual's genetics and biomarkers. By 2032, the model first made popular by Andrew Hessel's Pink Army Cooperative in the mid-2000s will be more mainstream. Pink Army, a community-driven, open-source cooperative for breast cancer treatment, uses synthetic biology and **virotherapy**—or using biotechnology to reprogram viruses to attack cancerous cells—to develop individualized cancer treatments tailored to each patient's DNA faster and more affordably. Other novel models, such as open-source biotechnology cooperatives like Genomera, will challenge the traditional business models of large pharmaceutical companies and will contribute to the practice of prescribing individualized therapies to treat a broad range of cancers by 2032.

Public Health in 2032: Actuating Community Health Systems

In 2012, public health data collected from a wide range of new and old information sources is used to support public health initiatives and policies that respond to health threats after the fact. In 2032, the role of public health surveillance will expand from monitoring and collecting data to creating actuating systems that can respond proactively to early signals.

PHALM

Public Health Automated & Locally Manifested (PHALM) manages the city's health collectively by scanning all citizens who have opted in to the system, looking for threats to individual and collective health, and taking subtle actions to neutralize them.

PUBLIC HEALTH AUTOMATED & LOCALLY MANIFESTED

This PHALM system is one of the first of its kind; in public spaces all over the city, it identifies people, objects, or activities that pose a health threat and takes preventive action.

With one of its 5,342 eyes, Public Health Automated & Locally Manifested, or PHALM for short, spots a person with a worrisome body temperature. PHALM identifies the person as Alexis Grajeda Goldman, an employee at Qool Software. It checks her social network feeds and monitors her body's movements. It then cross-references this information with Alexis's recent financial transactions, the weather in the neighborhood where she lives, and her commute conditions. PHALM denies her entry into the office.

> "Alexis, please head to the west veranda and work at a table with an uplifting view. I'll let you know the best time to go join your coworkers."

Alexis does as instructed and she does so happily, according to her gait. This pushes her overall well-being score up 20 points. PHALM changes the scoreboard displays throughout the building accordingly. It notes that the well-being indicators of a man on the third floor spike for a moment when he sees the new scores. PHALM knows what will come next. All over the building, those who notice the scores will experience a spike in well-being indicators, and people will see it in the numbers, then a temporary boost in productivity. But as the scores naturally sink back to a little above base level, stress indicators will spike as well. PHALM preemptively begins releasing mild lavender mist into the air, which softens the spike.

The floors with no scoreboard displays don't see this emotional cycle, with the workers there maintaining focus and using fewer resources as well. This discrepancy is significant enough that PHALM will suggest to the building administrators that they take down the scoreboard displays, forcing people to actively check the PHALM score on their own devices if they want to know.

This PHALM system is one of the first of its kind. It was launched in Aimswell in 2030 as a citywide system for monitoring citizens' health collectively. In public spaces all over the city, it identifies people, objects, or activities that pose a health threat and takes preventive action. Individual citizens can choose to opt in and allow PHALM access to their private data as well, in exchange for alerts and other nudges to help them meet health goals.

Many office spaces, such as those belonging to Qool, where Alexis works, have been able to opt in, too. Qool was one of the first companies to sign up and the results have been dramatic—every single employee has seen a marked increase in health indicators, equal or greater to what would result from an extra day of exercise per week. Other companies have taken notice, and as more office buildings have opted in, the results they've gotten have improved as well. In fact, adoption by companies is accelerating at such a pace that it's expected to cross the 50-percent line by the end of 2032.

THE CHANGING TECHNOLOGICAL LANDSCAPE OF PUBLIC HEALTH

Many of the same technologies mentioned in “The Changing Technological Landscape of Self-care” are going to have a transformative effect on public health.

Today, we have thermal-imaging cameras in certain airports to detect people traveling with a flu virus. And traffic lights in some areas have been programmed to respond to road congestion and aid in the smooth flow of traffic. However, we’re moving toward a world in which the flow of human beings throughout a city will be similarly managed in the name of public health.

Already, experiments are under way that aim to use **social network data** to better understand how health practices spread across a network of people, **mobility data** to anticipate flu and other contagious outbreaks, and **location data** pulled from mobile phones to measure environmental impact and exposure.[2] In 2032, most of these devices will have **sensor fusion technologies**, which will allow for a near real-time blending of single streams of sensor data into a fuller picture of the environmental conditions of a given place. And **wireless embedded cameras and sensors** in the built and natural worlds, as well as other kinds of computing embedded in the natural world, will create dynamic physical spaces that will be able to sense, record, and learn from the patterns of human activities. These spaces will be capable of interventions at the level of social networks and environments.

Traffic lights in some areas have been programmed to respond to road congestion and aid in the smooth flow of traffic. However, we’re moving toward a world in which the flow of human beings throughout a city will be similarly managed in the name of public health.

2. For more information please see the McKinsey Global Institute Big Data Report.
www.mckinsey.com/mgi/publications/big_data/index.asp

Part 3:
Your Place in Health Information Ecosystems in 2032

This report can help your organization consider the bigger picture and generate “outside the box” ideas. However, our artifacts from the future methodology, and its 20-year time horizon, are unfamiliar to many organizations. To ensure you get the most out of the forecasts in this report, we’ve created a guide to using these Artifacts from 2032 to create your own strategies for today that take the long view.

FIND YOUR STRATEGY

- **Anticipate the future.** Look for roots of our artifacts from 2032 in the world around you today. Consider the likely implications for health and health care of contemporary developments in technology.

- **Look outside your domain.** When considering the impacts of future change, look across all domains to get a comprehensive picture of the future. Assess how changes from outside your domain or industry will effect you.

- **Create your own scenarios.** Where does your organization fit in the world of 2032 that is forecasted in this report? Use our artifacts to inspire scenarios involving your organization or your specific field or industry.

- **Provoke conversations.** Several future developments will be challenging and disruptive to many people in health and health care today. Use our artifacts to jumpstart potentially intimidating conversations within your organization, or within your field, in a lightweight, fun, and nonthreatening way. Not everyone has to agree with the artifacts' assertions about the future for the resulting conversations to be useful.

- **Test your assumptions.** Take a look at your current long-term strategies. Are your assumptions consistent with what is depicted in our artifacts? Or are they contradictory?

- **Take the long view.** When making current decisions, ask not only if what you are contemplating will be helpful in the next quarter or the next fiscal year but also whether it will prepare you for developments that will happen by 2032 or leave you vulnerable to them.

- **Identify threats and opportunities.** Take inventory of your, or your organization's, assets and liabilities in the future depicted in this report. What threats and opportunities does this world of 2032 present?

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