

# 2020 FORECAST

The Future of Science,  
Technology, and Well-being



INSTITUTE FOR THE FUTURE

## HEALTH HORIZONS PROGRAM

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# 2020 FORECAST: The Future of Science, Technology, and Well-being

Science and technology (S&T) are always advancing.

But what will matter over the next decade is how technical

abilities and scientific perspectives converge to fight


illness and build well-being. This ten-year forecast map,

*The Future of Science, Technology, and Well-being*, explores

exciting convergences that are shaping how we respond to

health challenges in powerful ways by opening up new

scales of innovative action.



This map is designed to inspire you to consider new possibilities. As you work your way into this complex landscape, we ask:

- » How will we be able to remake our bodies and minds with new technology?
- » What will it be like to program our social networks to improve our individual and collective well-being?
- » What kinds of high resolution peeks and previews of health risks and assets in the environment will we have access to in the future?

While the potential for science and technology to improve health and well-being is impressive, it is not the whole story. What we need is to build our capacity and readiness to respond to these potential futures. We need to understand health—our aspirations for well-being and the emerging patterns of our resilience—systematically. This map charts a landscape to inform you and inspire your responses.

Beginning in 2009, the Institute for the Future's Health Horizons Program recognized this research theme—transforming bodies and lifestyles—as one of the most critical health challenges in the next decade, and science and technology will prove to be a powerful avenue of response.

## **THE CHALLENGE:** Transforming Our Bodies and Lifestyles

Globally, more than a billion adults and children are overweight or obese, and the consequences of chronic disease and disability are daunting. As more of the world population adopts a Western diet and becomes more sedentary, these problems will continue to spread. To counter this decline in our collective health, people will need to change how they live, eat, and take care of themselves.

At the same time, our population is aging. By 2020, more than 700 million people around the world will be over the age of 65. A subset of this older generation will aspire to live longer and avoid or delay the health conditions and difficulties traditionally associated with growing older. They will seek new approaches to extending their healthspans and quality of life.

At the far end of the spectrum from the sicker-than-ever to the better-than-well is the cadre of health enthusiasts who will strive to transform their bodies into peak performing systems. Their quest to maximize their potential will lead them to opportunities for enhancing their bodies and augmenting their health.

## **THE RESPONSE:** Science and Technology

Faced with this challenge, we will draw on scientific discovery and technological innovation to maintain, treat, and improve our health in fundamentally new ways. Science and technology are increasingly entangled with other response strategies we identified in HC2020: markets commercializing ideas at ever-faster rates, policies enabling and constraining development and commercialization, and commons finding new uses for S&T. But it is from science and technology—from interdisciplinary efforts and critical convergences—that truly new capabilities for addressing this challenge will flow.

Over the next decade, ubiquitous sensors, mental state measurements, and other data-gathering efforts will lead to dramatic improvements in how we monitor and measure our health. Continuing breakthroughs in epigenetics, neuroscience, nutrition sciences, and bioinformatics will give us radically improved techniques to understand our biologies. We will also benefit from breakthroughs in nanotechnology, synthetic biology, and bio-manufacturing that will lead us to new frontiers of regenerative medicine. These rapidly evolving areas of research, development, and delivery will provide tools to generate and analyze health data, precisely control environments, and shape our bodies and brains in powerful ways. While these are some of the most interesting areas we hypothesize will emerge in the next decade, the list is by no means exhaustive. This is a map of an exciting and dynamic landscape unfolding over the next decade and beyond.

# RESOURCES FOR BUILDING OUR CAPACITY FOR WELL-BEING

To confront the challenge of transforming our bodies and lifestyles, and to pursue the futures in which we can achieve well-being, we will need to bring a number of resources to the meet the challenge. This map focuses on four broad categories of resources, offered by science and technology, that we can use to increase our capacities in responding to this challenge: information, practices, people, and tools. The way we gather and make meaning of information, the practices we employ to take care of ourselves, our understanding of our identities and differences, and the tools we use to accomplish all of these things are pillars of advancement that we can use to build health and well-being.

Within each of these categories of resources, we've identified big stories: directional shifts suggested by our forecast clusters. These big stories float above the concrete possibilities that convergences in science and technology will enable. They give a sense of broad strategies for how to employ the categories of resources to the challenge of transforming our bodies and lifestyles. If information, practices, people, and tools are the kinds of resources science and technology will give us to expand well-being, then building, tinkering, discovering, and anticipating are the ways that we will use them.

## INFORMATION

### DEFINITION:

From the elaborate and growing structures of data we are amassing and using to the bite-sized communications that support health decisions, information is an invaluable resource for creating meaning, insight, and incentives.

### BIG STORY:

#### Building intuition

We've long struggled with making information actionable. But over the next decade, our quest for improved well-being will uncover the building blocks of a new, more intuitive relationship to health information. We will generate, analyze, and encounter information in gentler, more embedded, and more nuanced ways. With this shift, we will improve our capacities for being aware of our bodies and minds, and interpreting their signals. We will see research and contextual data that pave the way for more ecological models that can measure the true efficacy of interventions—validating or redefining “common sense” health knowledge. And we will see this new intuition built in the contexts of our lives.

## PRACTICES

### DEFINITION:

Over the next decade, our health practices will change as we experiment with incremental improvements to our bodies, networks, and environments. Our ability to test and iterate new practices is a central resource in the quest for well-being.

### BIG STORY:

#### Tinkering our way to well-being

In a future where more and more of us struggle with some ailment, one of our greatest assets will be our ability to accept incremental improvements. The health-changing practices in the coming decade will be less like heroic feats and more like tinkering: our health in perpetual beta. Early health adopters and more mainstream health enthusiasts will commonly fiddle, adjust, mend, and tinker with everything from their immune systems to their environments. While some manifestations of this tinkering will be extreme, the bit-by-bit nature of these practices will spill over, far from the usual suspects and early adopters.

## PEOPLE

### DEFINITION:

In the end the question of well-being is all about ourselves and those around us. Our identities will expand to reflect new awareness we will gain about our bodies and our brains. Ideally, our diverse capacities will be respected and valued by society.

### BIG STORY:

#### Discovering diverse capacities

Human beings have always found ways to pick out differences among themselves and to find strength in those differences. Over the next decade, advances in science and technology will help us to understand our differences at the level of cells, molecules, genes, and brain patterns, generating new measurements and new norms. These will add new layers to our identities, differentiating capacities, cognitive styles, mental aptitudes, and biological imprints. From these discoveries we will gain new insights into our vulnerabilities and strengths, and new understandings of our health and well-being.

## TOOLS

### DEFINITION:

The tools we bring together to produce good health will expand, enabled by life science breakthroughs, imaging techniques, and other fields delivering rapid innovations. We will perceive our risks, and respond to them, with ever-sharper implements.

### BIG STORY:

#### Anticipating health risks

One of the greatest resources for improving health and well-being over the next decade will be tools that enable foresight. The ability to predict potential side effects on an individual basis will change the existing processes for drug development. Early experimentation with simulation, imaging, and nanotechnologies will usher in an era of not only foreseeing potential health threats, but also preventing the onset of symptoms. The ability to intervene before any diagnosis or outbreak will create new arenas of personal and public health.

# HOW TO USE THIS MAP:

## Inform, Explore, Inspire

IFTF's Health Horizons Program has created this *2020 Forecast: The Future of Science, Technology, and Well-being* to highlight combinatorial innovations that will increase our capacities for well-being. The forecasts presented on this map will inform and inspire your thinking about how S&T developments may converge to enable responses for improving health and well-being. Use this map to navigate these rapidly shifting landscapes and anticipate unexpected innovations.

### WORKING WITH THE MAP:

**THINK** about new interventions across scales, or the spectrum for health interventions, and about the resources, or broad categories of assets that we can use to increase our capacities for well-being.

**FOCUS ON** the big stories that encapsulate science and technology forecasts.

**DRILL DOWN** into signals, the details that add up to the cluster forecasts, and scan the horizon for similar developments in your area of expertise.

**CONSIDER** the potential tensions, or conflicting implications that may arise given the cluster forecasts.

**REARRANGE** the cluster forecasts—the convergences of S&T developments that will lead to new health interventions—and the S&T advancements—the select advances in science and technology—to **CREATE** new forecasts.

## About the ...

### Institute for the Future

The Institute for the Future is an independent, nonprofit strategic research group with 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.

### 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 behavior 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.

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# KEY TENSIONS


Advances in science and technology create many opportunities for new products, services, and systems innovation; they also generate threats, conflicts, and dilemmas. To understand how S&T developments will help shape the future of well-being, we must consider not only the future possibilities, but also the potential tensions that science and technology generate. For example, science and technology innovations that promise to enhance our individual and collective well-being often exacerbate access and equity issues. Uneven social readiness for adoption and diffusion, appropriateness, and unintended consequences are unavoidable. Considering such dilemmas increases our capacity to respond to the challenges and opportunities of the next decade.


Here we identify four key tensions raised by our forecasts: oversupplying the engaged vs. reaching the uninterested; transformed capacities vs. real-world constraints; utopian optimism vs. uneven distribution; and best intentions vs. unintended consequences. These are broad tensions inherent to forecasts of science and technology and health. Within each of these we call out points of consideration for the health care sector, food system players, and the consumer packaged goods industry.

## OVERSUPPLYING THE ENGAGED VS. REACHING THE UNINTERESTED

New health interventions and practices resulting from advances in S&T will be experienced by a wide spectrum of people. A subset of early adopters will fervently embrace new tools, technologies, and services, regardless of whether they can detect measurable improvements in their health or well-being. Another subset of the population, however, will be less inclined to experiment with any of the new developments, no matter how dire their needs. Reaching the uninterested will remain a difficult challenge.


 **HEALTH CARE:** Whether the barrier is doctor buy-in or patient compliance, guiding or advocating any pattern of adoption will take a nuanced understanding of the desired users and their motivations. What are your capacities for discerning who needs something the most? Which strategies might you employ to persuade them, if necessary?


 **FOOD SYSTEM:** Healthy food is far from the default choice of many eaters, even those for whom food, and information about it, could be more vital to managing illness than medicine. How can nutritional information be communicated in a helpful way to those who could benefit the most from using it? What can get healthy food into the hands of those who need it, even if they don't want it sufficiently to seek it out?


 **CONSUMER PACKAGED GOODS:** When something has life- and health-changing potential, it will be needed by many more than the consumer segment most open to it. What kinds of creative re-packaging, strategic partnerships, and campaigns may help get products to those who need them most?

## TRANSFORMED CAPACITIES VS. REAL-WORLD CONSTRAINTS

Advances in science and technology will transform our capacity to sense and distribute information, to perceive disease and risk, and to literally remake our bodies. In theory and in the lab, these new capacities may appear limitless, but in reality they will run into concrete constraints and structural barriers. At the systemic level, these advances will potentially drive up health care costs, further strain already depleted environmental and economic resources, and exacerbate social tensions. Where people do gain access to cutting-edge technologies, they may lack access to other health necessities. While innovating low-cost, lightweight S&T responses will partially address this tension, the constraints of finite resources, geographical access, time, and cost will persist.


 **HEALTH CARE:** The tension surrounding technological innovation and its contribution to rising health care costs will remain. Over the past century, improved capacities to treat illness and create health have been accompanied by the perennial question of how to pay for it all. How will you determine which new opportunities justify investment of resources? How will you discern the real constraints to adopting new interventions?


 **FOOD SYSTEM:** Improving the nutritional content of food products is often coupled with an increased price tag. Unfortunately, this puts healthy products out of reach of those who need them most. Are there hybrid business models or collective purchasing platforms that could make accessible your innovations across the resource spectrum?

 **CONSUMER PACKAGED GOODS:** Many consumers will be looking for health and well-being products that do not absorb more time in their already busy days. Some will be looking for products that are good for both their own health and the planet with its resource constraints. How will you commercialize S&T advances while accounting for the diverse array of consumer needs and values?

## UTOPIAN OPTIMISM VS. UNEVEN DISTRIBUTION

S&T advances are chock full of world-changing promise, but in reality they will be unevenly distributed on a global scale. Social barriers, fear of the unfamiliar, information overload, and lack of infrastructure all push back against utopian visions. The transformative power of complex information will be hampered by the challenge of translating it to diverse audiences. Many individuals will not have access to potentially life-saving technologies. Extending the lifespan of the wealthy and connected while allowing the healthspan of the underserved to diminish may inspire social and political backlash.


 **HEALTH CARE:** How can health care systems across the globe manage mismatches between the optimistic expectations of patients and the readiness of providers, or vice versa? In the face of conflicting values, how will research be translated into medical practice and commercialization?


 **FOOD SYSTEM:** Advances in S&T are enabling companies to develop foods that positively impact health and well-being. As the ability to create more functional and personalized foods for health increases, consumers' readiness, understanding of, and desire for these advances will be highly uneven. How will you educate consumers and handle real concerns about risks while introducing new food products?


 **CONSUMER PACKAGED GOODS:** Technological optimism drives innovation, but this can result in a barrage of products, brand extensions, and service offerings. Confusion, lack of interest, and an inability to comprehend how competing offerings present unique value or benefits are symptoms of innovation overload in the consumer marketplace. What can you do to prevent consumers from being paralyzed by choice?

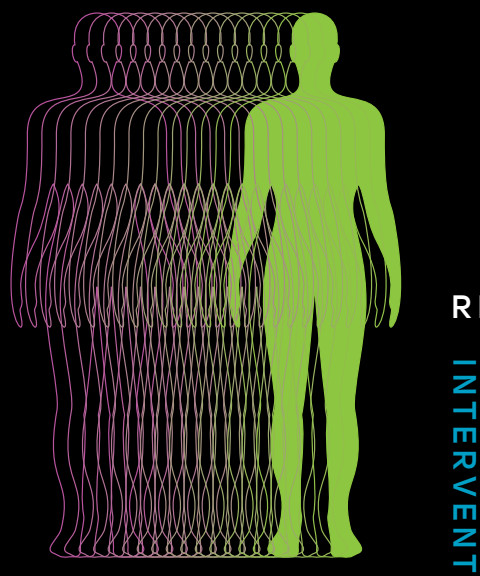
## BEST INTENTIONS VS. UNINTENDED CONSEQUENCES

There are always unintended consequences. As we tinker with our bodies, networks, and environments, we may find new problems confounding our best efforts at pursuing well-being. Technologies that enable increased prediction may stave off health risks but violate personal privacy. Intervening because a product, a person, or a network of people have a higher probability of contracting or spreading an illness may interfere with the free movement of people and goods. Radical success in one area of intervention may divert resources from other important health needs. And the street always finds its own uses: off-label and untested uses of new interventions will redraw or obliterate the lines between treatment and enhancement.

 **HEALTH CARE:** Science and technology are making it possible to use traditional medical interventions for enhancements or improvements. Already people are developing an intimate relationship with technology as it opens up new ways to reinvent our minds, bodies, and identities. How will consumers and health care organizations navigate the murky waters where medical necessity blends into self-improvement?

 **FOOD SYSTEM:** Once we start down the path of quick fixes for metabolic disorders, we could see the more stable, longer-term push for healthier foods being undermined. How can you remain agile as the relationship between food and health shifts continuously in unpredictable ways?

 **CONSUMER PACKAGED GOODS:** In the next decade, new materials will offer incredible product and packaging possibilities. While some may offer specific health and safety benefits, unintended health consequences may also emerge. Accidents and hidden costs may jeopardize the public image of not just one product but an entire technology. What internal capacities can you build to track emerging risks and opportunities?



## 2020 FORECAST

The Future of Science, Technology, and Well-being

### bodies

The complex combination of biological and information systems, regulated by sensitive feedback loops, that make us human.

Advances in science and technology will improve our biological health—our ability to treat our organs, cells, molecules, and genes. Our understanding of our minds—our thoughts, feelings, emotions, and meta-cognitive processes—will also improve.

### networks

The web of social relationships around us that influence our health for better or for worse.

Science and technology are expanding our understanding of network dynamics while expanding our social reach. We're gaining a better understanding of social effects on our health: effects of the health behaviors of those around us on our own health behaviors. Our peers, in both the physical world and blended virtual worlds, hold the key to amplifying or hampering our efforts to achieve well-being.

### environments

The physical spaces and geographic regions that contribute to both health benefits and health risks.

Built and natural environments are major contributors to our risk of illness and our capacity for resilience. This context of our health and well-being will blur the boundaries between personal and public health, self-tracking and epidemiology, healthy practices and health research, and consumer and citizen.



INSTITUTE FOR THE FUTURE

INTERVENTIONS

INTERVENTIONS

## information

### BUILDING INTUITION

From the elaborate and growing structures of data we are amassing and using to the bite-sized communications that support health decisions, information is an invaluable resource for creating meaning, insight, and incentive.

RESOURCES

### AUTOMATED NOURISHMENT

From guesswork to personalized nutrition

Preparing healthy meals may soon get a whole lot easier. Over the next decade, advances in biomonitoring, consumer kitchen technologies, nutrition science, genetics, and nutrigenomics will intersect with growing efforts of food companies to promote health. This convergence will push food consumption habits toward more personalized, healthful choices. New cooking gadgets, such as the 3D food printer, will allow custom, precisely targeted nutrition. Imagine a weight-loss program that incorporates a calorie counter, a blood sugar calculator, and optimal macronutrient ratios, all linked to a food-printing appliance.

**3D printing**

**Genomics and nutrigenomics**

**Continuous biosensing**

**Nutritional science**

**The Cornucopia 3D printer** from MIT's Media Lab takes raw ingredients and layers them to produce food.

**PhiloMetron** is developing a patch to measure calorie inputs and outputs to manage diet and exercise.

### ADAPTIVE ENCOURAGEMENT

From self-quantifiers to life doulas

Imagine a digital advisor that interprets your raw health data and offers continuous support along with interactive data visualization and recommendations for changing—and maintaining—daily routines or medications. Embodied in intelligent programs, mobile devices, and the cloud, a life doula (like a birth doula) will remind us of our goals in moments of weakness. It will offer suggestions and encouragement in context to help us make healthy choices. This kind of adaptive, personalized support will improve chronic illness management with automated diet tracking, in-home blood marker monitoring, and real-time analysis of genetic, metabolic, and protein data.

**Abundant mobile computing**

**Interactive data visualization**

**Simulations**

**Continuous biosensing and bioinformatics**

**Cloud computing**

**Track diet and fitness online** with DailyBurn.

**Fitbit** is a wearable tracker for fitness and sleep.

### OPTIMIZING HEALTHSPANS

From managing morbidity to living healthier longer

Life extension research will lead to the development of new drugs, vaccines, and therapies to add healthy years to the long-lived as well as the chronically ill. (Such research will investigate using the immunosuppressant drug rapamycin for late-onset rejuvenation, vaccines targeting the buildup of amyloid beta protein in Alzheimer's disease, and new stem cell therapies that change skin cells into neurons and printing on-demand organs for transplants). For the chronically ill, noninvasive, continuous glucose monitoring and granular insulin delivery technology like the patch pump will help increase years and quality of life.

**Peer-to-peer support**

**Life extension technologies**

**Continuous biosensing & adjusting**

**Regenerative medicine**

**The SENS Foundation**, started in March 2009, develops, promotes, and ensures access to regenerative solutions to the diseases of aging.

**Solo** is a discreet, flexible insulin patch pump with wireless control.

### CROWDSOURCED RESEARCH

From bench-to-bedside to bottom-up

Over the next decade, research on health interventions will expand beyond the clinical setting into the physical and virtual environments where health is most often managed. Lightweight research will leverage mobile technologies to enable remote monitoring and less invasive interventions, which in turn, will open up new avenues for research. Bottom-up, peer-to-peer research studies will be used more frequently, as they will better capture our daily routines and their health effects. The bench-to-bedside research model will be augmented by more rapid, integrated, and applied studies.

**Sensors and sensor networks**

**Peer-to-peer research**

**Abundant mobile computing**

**Cloud computing**

**Asthmapolis' Spirosout Inhaler Tracker** uses GPS to determine the time and location of inhaler use, and sends the information to personal diaries, the doctor, and an encrypted database used by asthma researchers.

**DIY BIO**

## practices

### TINKERING OUR WAY TO WELL-BEING

Over the next decade, our health practices will change as we experiment with incremental improvements to our bodies, networks, and environments. Our ability to test and iterate new practices is a central resource in the quest for well-being.

### PROGRAMMING IMMUNITY

From immune defense to immunotherapy offense

As viruses and autoimmune diseases proliferate, we will need more than a good immune defense. We will need to program our immune systems to attack disease. Already immunotherapy has "cured" some forms of cancer—interleukin-2, a molecule that signals key white blood cells to respond to infection, can send some skin and kidney cancer patients into complete remission. Personalized vaccines that target an individual's disease, along with beneficial bacterial infections to augment human immunity, will become mainstream.

**Synthetic biology**

**Open-source science**

**Stem-cell based therapies**

**Tailored medicine**

**Proleukin** is an FDA-approved immunotherapy for skin and kidney cancers.

**A neurosurgeon** at UCSF is testing use of vaccines made from patients' own tumors to fight brain cancer.

### CONTAGION HEALTH

From individual therapies to social interventions

As we come to view the community of people that surround us as not just relevant, but critical influencers on our health, our social networks, offline and online, will emerge as levers to improve or worsen well-being. Understanding how health habits and information spread through networks will lead to next generation social health recommendation engines aimed at identifying clusters of people with similar health profiles to extrapolate recommended health and behavioral interventions. These tools will enable individuals and companies alike to engage in computational modeling to simulate networks and design network-based interventions for optimal health results.

**Cloud computing**

**Peer-to-peer support**

**Sensors and sensor networks**

**Abundant mobile computing**

**Nicholas Christakis and James Fowler** explain the mechanics and importance of social networks.

**Lybba** makes it easy for patients, doctors, and researchers to connect and share information to improve patients' health.

### AUGMENTED ENVIRONMENTS

From information overload to customized feedback

Ambient technologies will track our biometrics and activities, analyze the resulting data to make sense of how environments and context shape health practices. Sensors embedded in everything from the walls in our homes to the clothes we wear will provide continuous wireless monitoring, and over time will lead to subtle shifts in the contexts of our daily lives in order to optimize health. Augmented reality technologies will enable health information to be overlaid onto real life. This may result in smart, subtle filtering to block out unhealthy foods, cigarettes or other tempting objects without our knowledge.

**Augmented reality**

**Abundant mobile computing**

**Sensors and sensor networks**

**Nano-technology**

**LookTel** offers voice cues to help the visually impaired recognize objects through phone cameras.

**Organic ink sensors** in a smart carpet detect if a person has fallen and is in need of help.

### TRANSFORMED CAPACITIES VS. REAL-WORLD CONSTRAINTS

Making biology safe, open, and accessible for citizen scientists, amateur biologists, and DIY biological engineers.

**Genomics**

**Nutritional science**

**Neuro-modulation**

**Research** showing that epigenetic imprints can be passed between generations has begun receiving press coverage in popular magazines such as *Orion*.

**The Roadmap Epigenomics Program** develops tools to measure epigenetic relationships between genes and environmental stimuli.

## people

### DISCOVERING DIVERSE CAPACITIES

In the end, the question of well-being is all about ourselves and those around us. Our identities will expand to reflect new awareness we will gain about our bodies and our brains. Ideally, our diverse capacities will be respected and valued by society.

### REPLACEMENT PARTS

From diseased or disabled to regenerated or enabled

Regenerative medicine will replace, restore, and enhance tissue and organ functions, dramatically improving patients' health and quality of life, and potentially reducing the cost of their care. Tissue engineering will heal diabetic foot ulcers, reducing the need for amputations; organs grown in a lab will ease our dependence on donor transplants; and tendons, cartilage, and bone regrown with autologous cells will be used to repair injuries and joints. Advanced prosthetic devices and biomechanical-based limb replacements will interface with the body's nervous systems to give users a range of natural function and movement.

**Utopian Optimism VS. Uneven Distribution**

**Advanced prosthetics**

**Regenerative medicine**

**Sensors and sensor networks**

**Neuro-modulation**

**DARPA** prototype of a prosthetic arm that can be controlled naturally and provide sensory feedback.

**The Pittsburgh Tissue Engineering Initiative** advises that regenerative medicine may ease the growing need for donor organs.

### MEASURING THE SUBJECTIVE

From defining neurotypicality to advancing neurodiversity

New ways of reliably measuring subjective states such as happiness, anxiety, or pain, and finding the neural correlates of personality and behavioral patterns will help us better understand our own capacities, potentials, and vulnerabilities in relation to other people. We will see new metrics and population-wide averages for neurotypicality, as well as recognition of a wide range of cognitive styles and mental aptitudes—that is, neurodiversity. The shifting definition of healthy brains may break down stigma as labels rooted in cognitive function and mental illness become functional identities.

**Diagnostic imaging**

**Metrics and standards**

**Neuro-informatics**

**Neuro-modulation**

**ASAN** activists like the Autistic Self Advocacy Network object to stereotypes of autism and suggest celebrating atypical brain functioning.

**Brain scans** show compassion and admiration are as deep-seated as fear or anger.

### EPIGENETIC IMPRINTS

From statistical associations to biological markings

Poorer long-term health outcomes have been linked statistically with a variety of environmental and social factors—from pollution levels to food availability to stress and income levels. Emerging research shows that these challenges can not only influence lifetime disease risk and mental health outcome but also leave biological imprints that are passed on to future generations. Over the next decade, the ability to see and track the biological impacts of social and environmental determinants of health will enable us to better understand the lasting effects of our surroundings and lifestyles on our bodies and those of our offspring.

**Genomics**

**Nutritional science**

**Neuro-modulation**

### EPIDEMIOLOGICAL FORECASTING

From field to field

The Global Viral Forecasting Initiative is an early warning system of disease outbreaks from the field.

**Thermal scanners** deployed at airports detect the heat signatures of passengers making preemptive quarantines possible.

**Abundant mobile computing**

**Sensors and sensor networks**

**Diagnostic imaging**

## tools

### RESPONDING TO FUTURE HEALTH RISKS

The tools we bring together to produce good health will expand, enabled by life science breakthroughs, imaging techniques, and other fields delivering rapid innovations. We will perceive our risks, and respond to them, with ever-sharper innovations.

RESOURCES

### DIAGNOSING THE PRE-SICK

From too late to early enough

Undiagnosed disease imposes a massive health and economic burden. Advances in imaging, magnetic-field measurements, lightweight labs, and nanotechnology are poised to help us detect disease before it's a problem. For example, Alzheimer's disease will be detected using functional MRI before the buildup of amyloid plaques in the brain becomes overwhelming; rare genetic diseases will be screened using inexpensive high throughput lab-on-a-chip technology. Further out, cancer diagnosis will happen using quantum dots so that cancer cells can be destroyed before they grow into a tumor.

**Diagnostic imaging**

**Genetic diagnostics**

**Synthetic biology**

**Nano-technology**

**Stanford and UCLA** are developing quantum dots that glow fluorescent when bound to cancer cells.

**A new method** for selective laser killing of bacteria targets bacteria with light-absorbing gold nanoparticles.

### BIOLOGICAL PREVIEWS

From genetic data to individual treatment

Genetic research involves making or finding mutations in the DNA code and studying the effect these mutations have on the body. Despite the torrent of data, the research has had limited applicability to individual patients. New techniques from regenerative medicine will enable researchers to create personalized cell lines from an individual's diseased cells and then test the effects of specific drugs or environmental factors on the diseased cells. The efficacy and side effects of a treatment will be able to be determined in the cell line before the patient is treated.

**Regenerative medicine**

**Genetic diagnostics**

**Bioinformatics**

**Tailored medicine**

**Cellular Dynamics International** derives fully functional human cells from stem cells for drug discovery research and toxicity testing.

**Massachusetts General Hospital** regularly tests tumors to match drugs to cancer types.

### ANTICIPATORY QUARANTINES

From maintaining boundaries to predicting flows

Quarantines have historically taken the form of spatial containment, often invoked in response to threat. Today, quarantines are being reimagined in the face of global pandemic diseases, food-borne illnesses, animal-to-human disease vectors, and even emotional contagions. Ubiquitous sensors, imaging technologies, and the ability to prescreen for diseases are giving us new tools to manage the movement of humans, animals, food, and materials. This will shift the focus for interventions from constructing boundaries after-the-fact to anticipating the movement of people, animals, goods, and diseases.

**Abundant mobile computing**

**Sensors and sensor networks**

**Social network dynamics**

**Diagnostic imaging**

### TENSIONS REMIND US TO CONSIDER NOT ONLY THE FORECASTS, BUT ALSO THE POTENTIAL CONFLICTS THAT MAY EMERGE AT THIS DYNAMIC INTERSECTION.

Remembering such dilemmas increases our capacity to respond to the challenges and opportunities of the next decade.

**VS.**

## 2020 FORECAST: The Future of Science, Technology, and Well-being Legend

This map highlights the advances in science and technology that will generate new insight into our individual and collective health and well-being, and enable us to improve health outcomes while opening new spaces for innovation and action. It places these advances in a matrix organized around three scales of response to health challenges and four resources for well-being.

### BODIES

SCALES OF INTERVENTION in science and technology will enable responses to health challenges at multiple scales. This map lays out forecasts systematically along three scales of interventions, from bodies to networks and environments.

### INFORMATION

CATEGORIES OF RESOURCES lay out four broad categories that we can use to increase our capacities in responding to this challenge: information, practice, people, and tools. These are the pillars of what science and technology bring to building a future of well-being.

### BIOLOGICAL PREVIEWS

13 FORECASTS explore new abilities to respond to the challenge and areas of innovation emerging from the convergence of advancements in science and technology. Each forecast represents a directional shift in our applications of these advancements.

### 3D printing

SCIENCE AND TECHNOLOGY ADVANCEMENTS point out disciplines, technology domains and scientific strategies that, in combination, point us towards areas of innovation. advancements

SIGNALS support each forecast with concrete examples that illustrate the science and technology advancements and show direction of the forecast as a whole.

### VS.

TENSIONS remind us to consider not only the forecasts, but also the potential conflicts that may emerge at this dynamic intersection. Remembering such dilemmas increases our capacity to respond to the challenges and opportunities of the next decade.