Today, digital technologies are our go-to tools for creation. To and fro, bits and bytes have become the most powerful and affordable medium to express ourselves, make art, and commercial products, and craft solutions to our biggest and created problems. Over the past decade, we’ve seen biology and information science rapidly converge. Today, this convergence is opening biology, bringing it out of academic and putting it into the hands of a new breed of innovators and designers, with their own motivations, priorities, and desires. From an engineer growing meat in a petri dish to a fashion designer cultivating clothing from bacteria and yeast, we’re already seeing what happens when biology inspires innovators from all walks of life.

The Exhibit of Future Creations inside. They hint at the landscape of the forces of change and signals of innovation that are happening today. In the next decade, anyone will be able to design and build with nature’s smallest and most sophisticated materials. The microbiome has opened a new frontier for personal care companies. Be on the alert for where we’re going. The range of innovations we’ll see emerge in the next decade.

**Welcome to a bio:made future**

In the next decade, anyone will be able to design and build with nature’s smallest and most sophisticated materials almost as easily as using a computer. We’ll edit genes and birth entire new organisms—and program life itself.

With this exhibit of Future Creations—our forecasts for this bio:made future, we invite you to tour this new landscape of the forces of change and signals of innovation that are happening today.
**ABOUT THIS EXHIBIT**

This Exhibit of Future Creations is an introduction to the bio:made future. Use it as inspiration to embrace biology because the urgent challenges of the new decade and create the biofuture you want to see in the world.

To get started:
- READ the Tech Revolution meets Bio Evolution section to get familiar with the future forces driving the bio:made evolution.
- EXPLORE the Exhibit of Future Creations sections. They hold the range of innovations and opportunities in the bio:made future.

**CONSIDER:** Balancing a bio:made future means to think through how to responsibly engage in your own bio creations.

This section highlights opportunities and pathways for anticipating future possibilities, to spark your imagination, and to unlock the potential in the bio:made future.

**WELCOME to a bio:made future**

In the next decade, anyone will be able to design and build with nature’s raw materials in a way once reserved for designers and artists. We’ll edit genes and birth entirely new organisms—and program life itself.

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**ABOUT TECHNOLOGY HORIZONS**

BioTech Revolution conditions a deep understanding of the potential and limitations of technology and the rapid pace of change to the future.

Today, we can manipulate the code of life to build new forms of life, to create new materials, and to edit our own biology. Tomorrow, the bio:made revolution will transform nearly every life form of interest on Earth—simultaneously causing disruption, to global warming, vaccine shortages, and antibiotic resistance—we will meet these challenges at the intersection of biology and technology, creating a bio:made future.

The urgent challenges we face at the personal and planetary levels are deeply rooted in biology. From lack of access to clean water and food systems to bioweapons of mass destruction, to global warming, vaccine shortages, and antibiotic resistance—we will meet these challenges at the intersection of biology and technology, creating a bio:made future.

**ABOUT THE INSTITUTE FOR THE FUTURE**

The Institute for the Future is an independent, nonprofit research group founded in 1983. Our mission is to study the future to help leaders and organizations make better decisions today. We do this by identifying emerging trends and discontinuities that will transform global society and the global marketplace. We provide our members with insights into business strategy, design, and innovation, and social trends that will arise from these changes.

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**ACKNOWLEDGMENTS**

I thank the following friends and colleagues for their ongoing contributions to the Institute for the Future:

- Jim Hartzler, Ed religious, and the team who work with me every day
- Peter H. Diamand
- The Institute for the Future team who work with me every day
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The Institute for the Future is based in Palo Alto, CA.
The biofabrication future is being shaped by four forces—abundant data, accelerated experimentation, democratized design, and the bioarma race. Together, they are amplifying, spurring competition and innovation, and opening bio to more innovators, driving us all toward bio:made futures, where biology serves both innovation and a tool for creation.

ABUNDANT DATA
Ubiquitous sensors provide new foundations of biological knowledge. Biology will soon be sensed at scale, and we are already seeing data and new data-facing effects. Sequencing the first human genome is a $30 million dollar effort and cost about $15 billion. By 2015, with over 220,000 genomes sequenced and the cost of genome sequencing dropping, the first human genome appears for $1,000. With the wave of open, accessible data that will soon be seeping into our beds, and into the industrial and governmental pipelines that will help us understand what we affect or afford our health, the new science microscopes of a city are now. We are able to see science, effectively. Advances in noise-reduction and artificial intelligence will also drive automated insights about the world in real time, helping us make sense of our bodies and health. The very fabric of data and creating valuable insights and rapidly delivering new capabilities through the cloud and networking will help us understand and manage all of our biology.

ACCELERATED EXPERIMENTATION
Increased investment and new activation technologies are dramatically accelerating the rate of experimentation. The 3D print industry during the second quarter of 2015—total of $23 billion—created the biggest uptick in inventing in decades to 10 years. The result of this financial has been part of innovation in industries, such as the large lab equipment market where 3D printing is now considered a norm. The availability of open-source software, libraries, and tools is enabling this evolution. With a wave of open-source software, libraries, and tools, we are seeing a wave of innovation that is not just in open-source and open-source libraries, but open-source and open-source tools. We are also seeing a wave of innovation that is not just in open-source and open-source libraries, but open-source and open-source tools. We are also seeing a wave of innovation that is not just in open-source and open-source libraries, but open-source and open-source tools. 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**FORECASTS**

**An exhibit of bio:made creations**

While bio has long been a crucible for creating medicines, materials, and foods, innovators will bring their own values and priorities to bio and, in doing so, vastly widen the applications of biology. This portion of the map is an exhibit of bio:made creations. It contains forecasts of a bio:made future, each of which is accompanied by two signals, present day projects, products or innovations that illustrate the change already underway.

**TECH REVOLUTION MEETS BIO EVOLUTION**

**ABUNDANT DATA**

Ubiquitous sensors provide new foundations of biological knowledge. Biology and IT have converged for over a decade, and we can already see democratizing effects. Sequencing the first human genome in 1990 cost $3 billion and took over 13 years. By 2015, with over 225,000 genomes sequenced and the cost of genome sequencing dropping to under $1,000 annually, a $5,000 genome is not far. But with the rise of cheap, wearable sensors on our bodies and in the natural world and the aggregation of data into meaningful patterns (big data!), we can begin to see how what we eat affects our health, how the collective microbiomes of a city's residents may affect asthma, and what is happening or not happening in our bodies. Essentially, data is creating a new platform of biological knowledge. Ubiquitous sensors, data, and computing enable us to capture and make sense of the living world and provide us new tools to address our health and the health of the world. The easy of collecting data and creating valuable insights will enable us to change the trajectories of many of our biggest and smallest problems. Over the past decade, we've seen biological and information sciences rapidly converging. Today, this convergence is opening biology, bringing it out of academia, and putting it into the hands of our biggest and smallest problems. Over the past decade, we've seen biological and information sciences rapidly converging. Today, this convergence is opening biology, bringing it out of academia, and putting it into the hands of our biggest and smallest problems. Over the past decade, we've seen biological and information sciences rapidly converging. Today, this convergence is opening biology, bringing it out of academia, and putting it into the hands of our biggest and smallest problems.

**OPEN-SOURCE SOLUTIONS**

While mainstream pharmaceuticals struggle to keep new blockbuster drugs, science startups are using the building blocks of biology to make open-source versions of diseases. Experimental approaches like open-source software or open-source tools are not new, but today, consortia are applying this approach in biology to improve health. Many open-source tools and platforms like the Rosalind Institute are improving the impact of the open-source drug discovery platform. Bio:Curious, as an early-stage, bio:made biodesign, is out of its first several small commercial ventures.

**RECOMMENDATION**: Do nothing. In the 2016 CRISPR Congress, a gene editing technique was lauded for its transformative potential. This system could be used for everything from eliminating arrhythmias in human beings to developing strength—or eliminating strength—or creating a bio:made future, each of which is accompanied by two signals, present day projects, products or innovations that illustrate the change already underway.

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**THE MICROBE OF THE MONTH**

The microbialism has opened a one-for-one opportunity for personal care companies. Do we lose the frontier for custom microbe-driven creams and serums to personal care companies? Are we losing the frontier for custom microbiome-driven health products? We have to ensure we hold to these territories, or we will lose the opportunity to work with the growing numbers of people who care about their microbiome.

**SUSTAINING JULY WITH MALI**

**DE-CANONIZATION**

Ancestral knowledge has always been central to human health. The ability to live long and healthy is dependent on the ways we live our lives. The solution is not to replicate traditional practices, but to modernize the practices for the present day. This portion of the map is an exhibit of de-canonized traditional knowledge, including ideas for bringing traditional practices into the modern era.

**COMING NEXT MONTH**: We are currently working to bring resources from around the globe to support our current initiatives, and we welcome contributions from all backgrounds.

**ABOUT TECHNOLOGY HORIZONS**

This research highlights opportunities and offers caution. Use it to help you anticipate future possibilities, to plan your investments, to assess your risk, or to shape changes in your business strategy.

**ABOUT THE INSTITUTE FOR THE FUTURE**

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We’re moving steadily towards a world in which anyone will be able to design and build with nature’s smallest and most sophisticated materials almost as easily as using a computer. We’ll still need and require new organisms—and perhaps life itself.

As we look out over the next decade, we have countless pressing challenges. And while biology has helped us meet challenges, such as food shortages in the past, we can now look to biology for answers to a wider array of our pressing issues. And as cutting edge biology becomes democratized, it creates an opportunity for all of us to get involved.

This Exhibit of Future Creations is a set of forecasts of a bio-made future, each of which is accompanied by two signals—present day projects, products or initiatives that illustrate that change is already underway. It can be used for inspiration for you to embrace biology to meet the urgent challenges of the next decade and help you create the bio-futures you want.

BALANCING A BIO-MADE FUTURE
The power of biotech over the next decade means responsible use is more important than ever. This future presents several challenges, however, this need to overcome those challenges can, in itself, become an important source of innovation. We must balance:

- Curiosity | Caution: Biological systems are complex and delicate. Tampering may have extreme unforeseen and adverse consequences. What can we do to proceed cautiously and prevent unintended outcomes?
- Sharing | Security: Genome sequences are valuable information that are likely to be targets of hacking. How can we ensure security and privacy for individuals?
- Investment | Openness: Beware of monopolies—no one entity should own what it means to be human. How can we encourage investment while preserving the openness and accessibility that leads to massive bio-innovation?

AN EXHIBIT OF FUTURE CREATIONS
Where the tech revolution meets the bio evolution

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With this Exhibit of Future Creations and forecasts for this bio-made future, we invite you to see this new landscape of the forces of change and signs of innovation that are happening today.

WELCOME to a bio:made future

In the next decade, anyone will be able to design and build with nature’s smallest and most sophisticated materials and code them into custom-sized machine instructions. These instructions can be downloaded and executed by any open-source and maker community equipped with open-source, and maker mindsets of transparency and sharing, prototyping with simple, reproducible, and accessible tools. Today, digital technologies are our go-to tools for creation. 1s and 0s, bits and bytes have become the most powerful and affordable medium to express ourselves, make art, and commercial products, and craft solutions to our biggest and most urgent problems. Over the past decade, we’ve seen biology and information sciences rapidly converge. Today, this convergence is opening biology, bringing it out of academic, and putting it into the hands of a new breed of innovators and designers, with their own instructions, priorities, and desires. From a culture of growing, eat at a party dish to fashion designer cultivating clothing from bacteria and yeast, we’re already seeing what happens when biology inspires innovations from all walks of life.

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ABOUT THE EXHIBIT

This Exhibit of Future Creations is an introduction to the bio:made future. Use it as inspiration to embrace biology because the urgent challenges of the next decade demand we create the biofutures you want to see in the world.

To get started:

READ THE TECH REVOLUTION MEETS BIO EVOLUTION section to get familiar with the future forces driving bio:made innovation.

EXPLORE the Exhibit of Future Creations and the Tech Revolution Meets Bio Evolution section to get a glimpse of the bio:made future.

CONSIDER the bio:made future to think through how to responsibly reprogram in your own care and biofutures.

This resource highlights opportunities to anticipate future possibilities, to spur your imagination, and to unlock the potential in the bio:made future.

The urgent challenges we face at the personal and planetary levels are deeply rooted in biology. From lack of access to clean water and food systems, to climate disruption, to global warming, vaccine shortages, and antibiotic resistance—we will meet these challenges at the intersection of biology and technology, creating a bio:made future.