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# Voices of biotech leaders

*Nature Biotechnology* asks a selection of leaders from across biotech to look at the future of the sector and make some predictions for the coming years.

Katrine Bosley, Charlotte Casebourn, Priscilla Chan, Janice Chen, Michael Chen, George Church, John Cumbers, Tomas de Wouters, Heather Dewey-Hagborg, Xavier Duportet, Abasi Ene-Obong, Arturo Elizondo, Jeremy Farrar, Bill Gates, Francesco Gatto, Sebastian Giwa, Jernej Godec, Silvia Gold, Emily LeProust, Jeantine Lunshof, Eddie Martucci, Michelle McMurray Heath, Jason Mellad, Veronika Oudova, Neri Oxman, Aviv Regev, Sarah Richardson, Christopher Thomas Scott, Jake Sherkow, Leah Sibener, Teresa Tarragó, Sharon Terry, J. Craig Venter, Spin Wang, Sajith Wickramasekara, Hakim Yadi, Luhan Yang and Bowen Zhao

What will be the most important developments in biotech business and its contributions across the globe in the coming years? In which areas will life-science enterprises make the biggest impact on society and why? *Nature Biotechnology* reached out to a selection of leaders representing a cross section of the industry and asked them to contribute their visions of the future. Some voices will be familiar; others, who may not, are young people who have taken leadership roles in their companies.

**Katrine Bosley:** In biotech, there's always a new kid on the block technologically. Right now we're at the cusp of the emerging maturation of machine learning and artificial intelligence (and soon, quantum computing) and their intersection with biology and medicine. The shiny new object of just five years ago—CRISPR—is now a

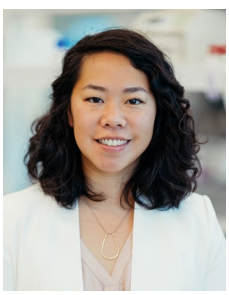
well-established and nearly rote technology, though we'll be learning and applying its potential for years to come. That often seems to be the case: breakthroughs introduce new targets, and that

gives way to the hard work required to understand the biology behind them.

**Charlotte Casebourn:** We cannot afford to settle for incremental improvements in healthcare, and traditional approaches to drug discovery and development won't cut it. Virus-based therapies comprise an emerging paradigm of treatments, with recent technical breakthroughs enabling the identification of efficacious, safe candidates ten times faster: as targeted, potent anticancer agents; for the delivery of effective gene therapies; and to combat infectious diseases. In realizing this substantial untapped potential, our industry requires diverse teams with the ability to collaborate across the frontiers of science and the commitment to ensure that these breakthrough medicines serve our global community.

Credit: Chan Zuckerberg Initiative

**Priscilla Chan:** We believe in a future in which everyone in the biomedical community has the tools they need to do their best work. In the past year, to address this pandemic, we've seen an encouraging shift from a traditionally siloed research approach towards more collaboration. The velocity of science and pace of discovery increase as scientists build on each other's advances. Fostering a culture of open science and collaboration will be key to tomorrow's breakthroughs that accelerate scientific progress, and in turn, our understanding of human health and disease.



Credit: Mammoth Biosciences

**Janice Chen:** Scientific advances in the field of genomics have led to the development of new tools for engineering biology with unprecedented speed and impact. The COVID-19 pandemic has brought the world together on a shared mission to build a response and recovery effort and proven that the development and scaling of new technologies can be supercharged with scientific rigor, partnerships and purpose. We still have an enormous responsibility to apply these learnings to other deadly diseases and ensure that life-saving diagnostics, vaccines and therapies can be distributed equitably around the globe.

**Michael Chen:** We face a 'valley of complexity' where making new medicines requires unraveling entangled systems, often connected by the immune system. COVID-19 was sequenced within weeks, but we still don't fully understand how it affects the lungs, brain, gut, nose and skin. The next generation of therapies will come from looking in the dark spaces between the traditional boundaries of biology. We can invest in scientists and entrepreneurs to look there now.

**George Church:** The revolution in reading and writing biology accelerates and ramifies: reading three-dimensional structures as easily as one-dimensional; bridging X-ray crystallography and cryo-electron microscopy (0.3 nanometer scale) with fluorescence in situ sequencing and oligopaints (10 nanometer resolution to multi-centimeter scale) to replace current 'RNA cell atlases' and conventional histology; writing genome enhancements; using machine learning plus array synthesis for millions of novel enzymes, antibodies, etc.; codon-recoding several species to be resistant to all viruses; making cell therapies and organs resistant to pathogens, senescence, and cancer; writing complex synaptic connectomes; and reviving ecosystems and sequestering carbon, possibly to preindustrial levels.

**John Cumbers:** In the 1990s the US automotive and semiconductor industries engaged in benchmarking to improve their competitiveness in relation to their Japanese counterparts. These successful initiatives used apples-to-apples metrics of technical performance to identify and promulgate best practices for improving industry-wide performance. For today's biotech companies, the competition is not with other countries or even with each other, but with the clock, as there are urgent needs to reduce food scarcity, improve health and substitute bioproducts for less sustainable alternatives. How much faster can biotechnologists turn this imagined future into today's reality? I believe that the answer lies in the biotech industry embarking on a new initiative focusing on benchmarking for R&D performance.

**Tomas de Wouters:** Translational needs in the microbiome field have started shaping a new niche in the contract manufacturing sector for this novel modality. Just like biologics, multi-strain microbiome products are shaped by their production process. In the area of multi-strain live biotherapeutics products, the technological challenges to produce 'bugs as drugs' are becoming evident. The development of new standards and increasingly sophisticated approaches will be key for successful translation of microbiome therapeutics. Technological innovations to produce multi-strain products at scale are going to be a 'make or break' requirement for this young industry once clinical programs move towards commercialization.

Credit: © Ana Brigida

**Heather Dewey-Hagborg:** There is a lot to be excited about. COVID-19 testing and vaccine development outpaced expectations, and mRNA has now become a household word! But with the pervasiveness of testing comes extraordinary risks to personal privacy. It is vital that we safeguard the fluids and data of the billions of COVID-19 test samples circulating worldwide. Furthermore, as vaccine

rollout has offered a breath of relief, we must be more vigilant than ever to protect human rights. 'Vaccine passports' offering differential access to mobility may seem like a welcome break from lockdown, but we must be careful to consider who is excluded from the privileges granted to the immunized. Communities of color often face a lack of access while others are prevented by physical condition, including many women prevented by reproductive status. This is a grand challenge: how to design these new systems that will very likely remain in place for many years to come with priority given to social equality.

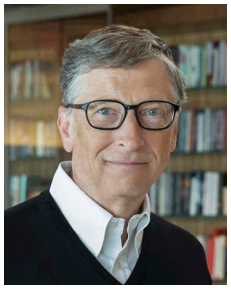
**Xavier Duportet:** We live in an exciting time for microbiome research, as the field moves beyond correlations towards demonstrated causal relationships between diseases and the presence or absence of specific bacterial genes in the gut or on our skin. In the coming years, we will see the arrival in the clinic of new technologies able to address unmet needs in oncology, central nervous system disorders, autoimmunity and inflammation by targeting the bacterial etiological agents with extreme precision.

**Abasi Ene-Obong:** It is my belief that genomics will not only accelerate scientific discovery but also democratize discovery as we begin to carry out population genetics work in diverse populations that typically have not been a source of scientific discovery owing to obstacles such as lack of infrastructure, access to capital and talent. These obstacles are diminishing, and the world is now a different place than it was 10 years ago and will continue to evolve. Population genomics in diverse populations will lead to new discoveries, and scientists from diverse populations will significantly contribute to science.

**Arturo Elizondo:** The most egg-citing developments will be the advent of Food 2.0. The age of molecular food is just beginning to unfold. We're just beginning to harness the potential of biotech to look at food at the molecular level––at the level of the individual protein rather than the whole product. For the vast majority of human history, we've looked at meat, milk, eggs, fruits and vegetables as monoliths that should be consumed as such. However, there are proteins that have incredible properties that live 'trapped' in these products just waiting to be unshackled.

**Jeremy Farrar:** Over the past year, we have witnessed science advance at a staggering pace to improve health, protect lives and provide a way out of the pandemic. This has been possible thanks to years of investment in discovery science and more open working across scientific boundaries and national borders. New platform technologies, including nucleic acid technology and viral vectors as delivery systems, herald an exciting new era where the distinction between a 'vaccine' and a 'therapeutic' will become increasingly blurred, opening up exciting opportunities for prevention and treatments of infectious and other illnesses. The year has also highlighted how innovation in other disciplines—for example, oncology—can benefit the treatment of infectious diseases, and vice versa. Innovative approaches to clinical trials and trusted regulation is critical to ensuring great science is translated into clinical benefit. To make sure these scientific advances are available to the maximum number of people who stand to benefit, we need to support innovation in manufacturing technology, as well as the greater global distribution of that capacity. Within three years, I believe we can go from viral sequencing to having safe and effective vaccines and therapeutics in 100 days. By 2030, we need to set a goal of achieving that within 30 days.

**Bill Gates:** For most of human history, the world has focused on fighting disease and trying to grow enough food for everyone. Threats like COVID-19 and climate change are challenging these efforts in new ways—but also driving unprecedented innovation. mRNA technology delivered a vaccine in record time and may also enable antibody production. Gene editing and technologies such as CRISPR promise to extend treatment to millions of people suffering with HIV and sickle cell anemia in low-resource settings. Gene drives may be the key to one day eradicating malaria, and genomics-assisted breeding is helping develop crops that can withstand rising temperatures and drought. Breakthroughs like these will move us toward a world in which all people have the ability to lead healthy and productive lives.



Credit: Gates Notes

**Francesco Gatto:** Two uncertainties have historically hindered the biotech industry. Do we have enough confidence that our new biotechnology will be safe and effective? Will we have sufficient market protection to justify years and money spent for its development? To me, current regulatory and intellectual property frameworks appear sufficiently mature and predictable to allow reliable and optimistic planning. Wet-lab work will be a commodity, with robot scientists and artificial intelligence–driven research boosting the number of new ideas. Oiled and well-funded ecosystems (academia, science parks, etc.) are spreading in East Asia and Europe, filtering the most promising ideas to create new ventures. I predict that fundamental biology will become a limiting factor for innovation, opening the exciting prospect of more basic research sponsored by industry.

**Sebastian Giwa:** Biomedicine and research can be transformed by the ability to control biological time through cryopreservation and suspended animation, allowing storage of living systems from tissues to organs to whole organisms in fully functional states. These

technologies can overcome constraints in transplantation, biomanufacturing, regenerative medicine, disease research, drug discovery, fertility protection, trauma care, mass casualty medical countermeasures and human space travel. A modern-day 'Apollo program' has begun to make progress on this challenge, with >$100 million in funding so far from a coalition of government and philanthropic sources. This program applies a convergence of exponentially advancing technologies to achieve the audacious goal of biostasis.

Credit: © Jon Chomitz

**Jernej Godec:** Technological advances unlocking the historically undruggable proteome are incredibly exciting to watch as we envisage the potential they can bring. Together with biological discoveries highlighting the pathogenic drivers of various disease subsets and matching patients to their tailored therapeutic interventions, these innovations can help generate the next wave of effective medicines.

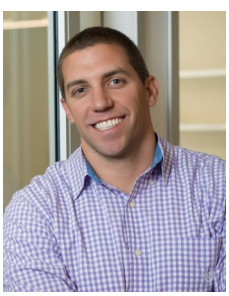
**Silvia Gold:** Biotech is a relevant change maker in our lives, closest to us in medicine but influencing agriculture, food, the environment and indeed all of our everyday lives. In Chagas disease, innovations in diagnosis, thanks to biotech, provide key differences in opportunities to treat patients. This is especially opportune in the diagnosis of newborns, which enables us to avoid loss of life. Today's incredibly fast development of diagnosis, vaccines and therapeutics against COVID-19 was possible only because of the opportunities biotech gave. It also represents an economy of trillions of dollars, big rewards for investors, and highly qualified employment. In our medical world, I think the major future compromise in terms of equity is to manufacture therapeutics at more affordable prices to allow access to better medicines for all.

**Emily LeProust:** We've seen both devastation and collaborative innovation through

COVID-19, which has spotlighted the power and promise of life sciences R&D. I believe the 21st century is the era of biology. Although we are still in the midst of a global pandemic, moving forward requires a wider focus on healthcare through new diagnostic and therapeutic methods for all diseases, as well as elevating our approach to sustainability through biological manufacturing. Through the exponential scientific advances now available, cancer can become a chronic disease; all plastic can be replaced by protein-based materials that do not depend on fossil fuels; and meaningful jobs can be created within a thriving bioeconomy.

Credit: © Aram Boghosian

**Jeantine Lunshof:** Novel bioengineered constructs are at the brink of translation into biotechnological processes and products. The call for 'ethics' gets louder. But to be more than decoration or alibi, ethics assessment—as one key component of regulation—requires a thorough conceptual understanding of the nature of biological engineering: philosophy can answer that call as collaborative ethics on the work floor or from the helicopter. Biological engineering and biotech pose an exciting challenge and opportunity to the humanities to bring the toolbox and get involved, adding a new dimension both to the life sciences and to their own disciplines.



**Eddie Martucci:** We're in the midst of a new biomedical moment: we have an increased understanding of, and now ability to leverage, how technology and our world directly interact with human physiology. The parallel rise in digital healthcare is shattering logistical barriers. Combined, these factors demand a major change to our preconceptions of how mechanism-based medicine looks and feels—especially for behavioral and mental health. With scientific barriers crumbling, the first examples of physiologically targeted digital treatments in market, and a greater-than-ever societal appreciation for the multiplicity of stresses we all face on a daily basis, consumers are hungry for better and new options. We'll see acceptance and demand, much more quickly than many think.

**Michelle McMurray Heath:** From medicine to agriculture to energy, the coming biotech revolution will vastly improve people's health, change how they go about their daily lives, and better preserve our planet. Yet for this revolution to be successful and sustainable, its benefits must be felt across all communities in ways that are just, impactful and inclusive. Improving access to scientific innovation is a social justice issue. If biotech advances reach more people in equitable ways, millions of families around the world stand to benefit, and science will be seen as society's leading catalyst for change.

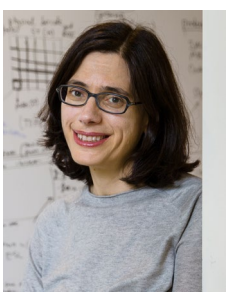
**Jason Mellad:** Equity, diversity and inclusion will prove to be the most disruptive innovations of the 21st century. Numerous studies have demonstrated the benefits of welcoming more women and people from a wider range of ethnicities and socioeconomic backgrounds into positions of power in biotech, whether academic or commercial. Leveraging this largely underutilized talent pool and developing new solutions that address the distinct clinical needs of historically underserved communities will help us close the health gap and access new markets. We all must actively support the next generation of translational researchers, startup founders, senior executives and life science investors who will make this vision a reality.

**Veronika Oudova:** The future for many new biotech companies will increasingly be driven by the lean business concept. Biotech is crucial to ignite the paradigm shifts that our world requires, but we must not forget

that great science alone doesn't make a successful company. I believe that we will see more alternative and innovative business models in the industry in the same way we already do in the microbiome sector and that we will leverage learnings from other tech sectors to increase our success rates and to accelerate our reach to consumers.

Credit: © Noah Kalina

**Neri Oxman:** In a postpandemic planet, architects are called upon to design complex systems rather than stand-alone buildings, self-regulating structures rather than static constructions, ecological niches rather than human settlements. Biotech will play a key role in perpetuating the conditions for life on Earth and beyond as we strive to fuse the grown and the built, through the invention of technologies designed to preserve genetic richness and complexity in the form of stored bits and digitally fabricated atoms. Such unity will result in a new ecology fusing nature-grown and industrial materials, structures and systems: a material ecology. Only if and when human-produced mass will be grown and constructed as biocompatible matter will we be able to reverse the threats of the sixth mass extinction. It is time to mother nature.



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**Aviv Regev:** We are at an inflection point when there is an incredible opportunity for the entire biomedicine ecosystem to go beyond delivering additive benefits and to have a multiplicative impact on biomedical understanding and patients' lives. I'm particularly excited about our collective ability to make the challenging process of discovering and developing new medicines for patients more predictable, using four levers: human biology; massively parallel, high-resolution lab methods; novel therapeutic modalities; and advances in computation and mathematics. Through these levers, and a continued focus on collaboration and interdisciplinary approaches to R&D, I believe we can deliver better medicines more quickly and make a greater difference than ever before in the lives of people suffering from disease.

**Sarah Richardson:** I am stoked that bioengineering hit a wall in 2020. When we acknowledge it, we can overcome it! I suggest we progress by going full retro, remodeling our approaches to leverage lessons learned from centuries of agriculture. The people who coaxed corn from teosinte and dogs from wolves did not need to know at a molecular level how nutrition or companionship worked because they understood cooperation and mutual benefit. The amazing tools we've built this decade for molecular manipulation will work radically better when deployed to enhance inborn skill, rather than to introduce novel function. Domestication is the once and future king.

**Christopher Thomas Scott:** The US National Academies assert that governance of human genome editing (HGE) should be informed by substantive public engagement, dealing with "both facts and values and ... how anticipated changes will affect the things people value." Over the past year, a group of about 45 CRISPR experts have been using methods called anticipatory governance to peer into the future. Neither prediction nor forecasting, anticipatory governance focuses on future-oriented reflection of the relationships between scientific, technical and societal change. Our plan is to posit multiple, plausible futures for HGE and then deliberate on these futures with the public. Thus, governance of HGE becomes co-produced and enables the public to voice its concerns about looming socio-technical change.

**Jake Sherkow:** The most substantial challenges that lie ahead for new biotechnologies are likely not scientific or technical, but legal. Many new biotechnologies outstrip older regulatory definitions, such as how to categorize *n*-of-1 therapies. Different countries permit some technologies but not others, leading to difficult issues about biotechnological 'tourism'. And intellectual property and trade secrecy protections for new biotechnologies present their own difficulties to investment and the public health. Putting these together in a world of massive political and social upheaval, concurrently with skepticism of scientific expertise, presents a challenge to realizing the full benefits of these technologies.

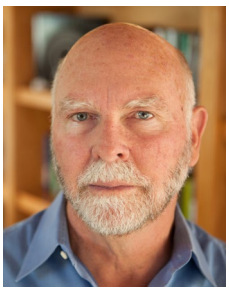
**Leah Sibener:** The emergence of technology and computation's enormous influence on the acceleration of biological and therapeutic discovery has poised the future of drug development to embrace innovation across the development and regulatory process. The impact of high-resolution biological datasets, as well as advancements in rapid and iterative protein and cell engineering platforms, has uncovered numerous potential avenues for therapeutic targeting. To realize the promise of translating next-generation therapeutics into the clinic, the processes of drug development, manufacturing and trial design will face a challenge to innovate and keep pace with the constantly growing field of novel targets and complex engineered therapies.

**Teresa Tarragó:** Being able to analyze what happens inside the human body at the omics levels (the transcriptome, the epigenome, the metabolome and other omics) will lead to major advances in personalized and precision medicine. The power of omic technologies

to provide information on a molecular level has the potential to transform medicine from traditional symptom-oriented diagnosis and treatment of diseases toward disease prevention and early diagnostics. All this knowledge will be translated into health insights and highly personalized lifestyle recommendations to improve the health status and well-being of the population by focusing more on prevention of chronic illnesses than on their treatment.

Credit: © Elizabeth Terry

**Sharon Terry:** I envisage a future where people will be recognized as the core constituents in the discovery, development and dissemination of solutions for better health. The priorities of individuals and their communities will drive the decisions and activities of an industry aligned with what matters most to people. These will be inclusive and relevant to the most vulnerable people and communities before their needs become a crisis. Although this may sound naïve, it becomes not only the right thing to do but, because incentives align with human interest, the best thing to do.



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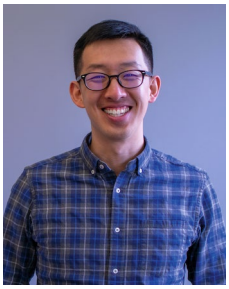
**J. Craig Venter:** The worldwide death toll for COVID-19 just surpassed three million deaths, and we still have no national nor international screening for emerging infectious diseases, so we are ill-prepared for the next pandemic. New DNA blood tests will soon be able to detect cancers at the earliest stages, especially when coupled with the latest magnetic resonance imaging (MRI) technology. We need to disrupt the entire medical industry to change the reimbursements for prevention and early treatment. If we do this, it will save trillions of dollars and countless lives. Likewise, new science is critical for dealing with climate change, or disease, death and famine will be exacerbated.



**Spin Wang:** Global biopharma companies seeking to transform their lab operations, replatform their data to the cloud, and accelerate drug discovery are challenged by data locked in organizational and technological silos. Struggling with tedious and error-prone manual transcription or fragmented and costly integrations to move the data in their R&D workflows, lab organizations suffer from an inability to apply advanced data science, artificial intelligence and machine learning to their research initiatives. A movement is forming around an R&D data cloud to meet challenges in data science and accelerate drug discovery to improve human life.

Credit: © James Rice, Benchling

**Sajith Wickramasekara:** 2020 gave us just a glimpse of modern life science's potential to deliver transformative breakthroughs in record time. In the coming years, life science will rewrite the way we live—not just the medicines we take, but the food we eat, the clothes we wear, and the energy that powers our lives.

**Hakim Yadi:** Precision medicine, where healthcare treatments are tailored to the individual, has until now been applied to only a handful of medical conditions. What if it could be applied more widely? The ability to put 'software as a medical device', in the form of an app, in the hands of any patient with a smartphone creates an opportunity for digital companions to be prescribed alongside traditional therapeutics, enabling real-world data integration into care regimens more precisely tailored for individuals. This approach has the ability to level the playing field, providing universal access to the highest quality care—usually accessible only to the few.

**Luhan Yang:** Advances in multiplexable genome editing offer exciting opportunities to rewire mammalian cells to perform novel biological functions. I am excited about ongoing work to engineer immune-privileged allogeneic cells and xenogeneic organs to develop therapies for patients in need. Critical next steps include uncovering the pathways underlying immune rejection, adjusting the makeup of cells and organs to evade rejection by the immune system, and ultimately developing cell therapy products with novel functions to treat a variety of different diseases.

**Bowen Zhao:** Live biotherapeutics products are becoming the new favorite of the pharmaceutical industry, as a result of booming research in microbiome–host interactions over the past decade, the potential druggability of which has fueled bright prospects in many equity research reports. However, we should beware research funded by corporations that lacks the necessary depth and patience needed for scientifically robust interventions. A considerable portion of products in development right now are basically versions of simplified or standardized fecal microbial transplants. More efforts to develop tools, such as quantitative metagenomics, culturomics and reference samples, are needed to unleash the full potential of this emerging field. ❐

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