# AC vs Vestavia Hills GJ

## AC

### Plan

#### Plan: Member nations of the World Trade Organization should reduce IP protections on genomic medicines

### Advantage – Innovation

#### Advantage is innovation:

#### A huge influx of patents is coming – most recent data and trends from this year

Mischel 4/27 [(Fiona Mischel, Editor-in-Chief of SynBioBeta. She frequently covers sustainability, CRISPR research, food and agriculture technology, and biotech for space travel.) “Who Owns CRISPR in 2021? It’s Even More Complicated Than You Think” SynBioBeta, 4/27/2021. https://synbiobeta.com/who-owns-crispr-in-2021-its-even-more-complicated-than-you-think/] BC

Still Want To Patent CRISPR? Here’s What You Need To Know

The biggest challenge for anyone trying to sort out CRISPR patent rights is fully understanding just how many patents there are.

A search in the USPTO revealed 262 patents or patent applications listing CRISPR-Cas9 and over 5,000 general CRISPR patents. And these are only the patent applications for Cas9. This doesn’t include the growing number of patents for other Cas molecules or Cas molecules yet to be discovered. This also doesn’t include patent applications in other big synthetic biology regions like China, Europe, the UK, and Israel.

The competition for CRISPR patents is unlikely to diminish in the future as more companies and academic centers clamber to join the race. The race has become increasingly global with more countries filing for CRISPR patents—new patents are filed at a rate of 200 per month.

What isn’t clear is how these enormous numbers of CRISPR patents will affect the future of science. Will they hamper progress by limiting the commercial use of the technology, or will researchers prevail and make new therapies accessible to everyone? When the dust settles—if it does at all—the hope is that CRISPR technology will be accessible for a wide range of applications at a competitive cost. The power to engineer biology should not be limited to the very few. We are now in the Age of Biology. If we are to build a better future, we cannot leave the fundamental promise of science in the dust.

#### Makes development of CRISPR impossible – 3 warrants

#### Patent disputes are imminent -- other entities and foreign governments get involved ensure conflicts

Stramiello 18 [(Michael, PhD, an intellectual property litigation associate in Washington, DC. His practice focuses on the life sciences industry.) “CRISPR: The New Frontier of Biotechnology Innovation” American Bar Association, Jan/Feb 2018. <https://www.americanbar.org/groups/intellectual_property_law/publications/landslide/2017-18/january-february/crispr-new-frontier-biotechnology-innovation-digital-feature/>] BC

As the UC-Broad interference winds down, CRISPR watchers should not lose sight of the USPTO, where more challenges may wait in the wings. For example, at least one ex parte reexamination against a foundational patent owned by Broad has already been granted (and suspended until the interference concludes). There is also a looming threat of additional interferences, as mentioned in recent USPTO communications19 and acknowledged in the pre-IPO disclosures of all three CRISPR-centric biotechnology companies publicly traded in the United States (i.e., CRISPR Therapeutics AG, Editas Medicine Inc., and Intellia Therapeutics Inc.). Potential dark horses identified in those filings include: (1) Rockefeller University, a joint applicant on certain Broad applications; (2) ToolGen Inc., whose suggestions of interference against Broad are still pending; and (3) Vilnius University, which has its own US patent for use of CRISPR/Cas9 systems and is party to a cross-licensing agreement with one of UC’s licensees. Other entities may also come out of the woodwork with freedom-to-operate strategies that challenge key patents via inter partes review or post-grant review.

Additional CRISPR disputes will happen overseas in 2018—and if patent grants are any indicator, foreign agencies might not simply follow the USPTO’s lead. The European Patent Office’s (EPO’s) Opposition Division (OD) will kick things off on January 16, when it hears oral arguments in oppositions lodged against a foundational patent owned by Broad. Among other things, challengers have attacked the purported novelty of Broad’s claims, a determination that may hinge on whether Broad validly claimed priority to two of its early applications. If it did not, at least seven of Broad’s other opposed patents may be vulnerable too. The OD has already issued a preliminary opinion indicating that it expects the oppositions to succeed.20 While that opinion is nonbinding, European analysts have stressed that it is usually “very difficult” to sway the OD from its preliminary views.21 In any event, Broad will not be the only foundational patent holder fighting to keep its rights alive across the pond in 2018, as the EPO has also granted noteworthy patent rights to UC, Sigma-Aldrich, and Cellectis, thus opening nine-month windows for would-be challengers to file post-grant oppositions. The fight over UC’s patent, which controversially covers use of CRISPR in both prokaryotes and eukaryotes, may be especially heated. It has already withstood over a half dozen third-party observations (including some filed by Broad),22 and at least two groups have now filed post-grant oppositions.23

China, home to the world’s second-busiest CRISPR patent landscape (after the United States), may host similar turf wars in 2018. UC and Broad, among many others, are already on the scene and may be drawing up battle plans. While Broad’s applications remain pending, China’s State Intellectual Property Office announced in June its intention to grant UC a patent covering CRISPR/Cas9 methods and compositions for applications in any environment. One of UC’s key licensees in human therapeutics praised the decision as “further global recognition that [UC and its collaborators] are the pioneers in the application of CRISPR/Cas9 in all cell types.”24 Not missing a beat, Broad issued an ominous reminder that “[i]n China, patents are subject to invalidation proceedings after they are issued.”25

#### IP disputes foreclose research collaboration between universities, which has historically enabled critical scientific breakthroughs

Sherkow 17 [(Jacob, Professor of Law at the College of Law and Affiliate of the Carl R. Woese Institute for Genomic Biology at the University of Illinois, where his research focuses on the legal and ethical implications of advanced biotechnologies, especially as related to intellectual property. He is a leading expert on IP protection for genome-editing technologies, including CRISPR. He is the author of over 60 articles published in both scientific journals and traditional law reviews, including Science, Nature, the Yale Law Journal, and the Stanford Law Review. Since 2018, Sherkow has also been a Permanent Visiting Professor at the Center for Advanced Studies in Biomedical Innovation Law (“CeBIL”) at the University of Copenhagen Faculty of Law.) “Patent protection for CRISPR: an ELSI review” Journal of Law and the Biosciences 12/7/2017 <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5965580/>] BC

One notable aspect of the CRISPR patent dispute is that it is, by and large, a dispute between academic research institutions. It pits lawyers representing the University of California against lawyers representing the Broad Institute of MIT and Harvard.22 To be sure, university rivalries are common.23 But because universities share among themselves a larger mission to create and disseminate knowledge to the public, litigiousness among them has been historically rare.24

University-against-university patent disputes, like CRISPR, complicate interinstitutional research agreements on several levels. First, they have the potential to chill formal interinstitutional research collaborations among universities if the institutions cannot agree on intellectual property issues beforehand.25 Universities may simply be unwilling to enter into such agreements in the first instance, or, perhaps more perniciously, discourage their faculty from informally developing such networks.26 While the empirical evidence for such a diminishment in collaborative efforts is slight—difficult to demonstrate, in part, because it requires the proof of opportunities not taken by universities—some recent survey data have found that ‘institutionally mandated [materials transfer agreements] put sand in the wheels of a lively system of intra-disciplinary exchanges of research tools’.27 Aside from this, there is substantial anecdotal evidence of institutional difficulties in creating such agreements.28 It stands to reason that, at least in some instances, these difficulties have ended some collaborations before they could begin. More immediately, this is a current issue with the CRISPR patent dispute given some internal dissention between Doudna and Charpentier's respective institutions concerning the intellectual property involved. Although Doudna and Charpentier filed their joint patent application in 2012, their institutions did not formally assent to a cross-licensing agreement until December 2016.29 If assenting to a cross-licensing agreement for a single piece of technology has proved difficult, it is unclear how the two institutions will deal with one another on future collaborations.

Second, even with some friction between universities over obtaining patents for their researchers’ work, it has been rare for universities to sue one another regarding inventorship—until now. In 2011, for instance, the University of Utah sued the Max-Planck Institute concerning inventorship over a foundational group of patents concerning RNA interference technology.30 And since 2012, Stanford University and the Chinese University of Hong Kong have battled one another over lucrative patent rights to noninvasive prenatal genetic diagnostics.31 That dispute—despite several rounds of appeals—is still ongoing.32 Such patent disputes are costly, high stakes, and high profile. And while the CRISPR patent dispute itself is not a cause of such conflict, it has become emblematic—and potentially prophetic—of the tenor of such disputes today. Avoiding them in the first instance is a sensible institutional priority. But that sometimes comes at the cost of avoiding one's colleagues.33

Third, even apart from the administrative institutional level, patent disputes like these damper the culture of scientific collaboration, clearly something of tremendous import to modern science.34 Putting a price on a loosely defined culture of scientific collaboration is difficult—its loss is difficult to quantify. Nonetheless, many of the most significant breakthroughs of the past century arose in part from a culture of scientific openness and collegiality.35 Abandoning that in favor of inuring patent rights to researchers from a single institution seems, at best, unwise. Relatedly, it may erode scientists’ penchant for honest, if critical assessments, of their own work among collaborators and colleagues. A key piece of evidence used in the U.S. CRISPR patent interference against the University of California was a single one of Doudna's public statements that her collaborators ‘weren’t sure if CRISPR/Cas9 would work in eukaryotes—plant and animal cells’.36 That statement has now echoed throughout laboratories across the USA as a cautionary tale against critical reflections of one's work—at least while patents are pending.37

Lastly, patent conflicts’ hindrance of interinstitutional collaborations may simply be costly. Today, some research benefits from economies of scale, such as where expensive equipment can be shared among institutions.38 The New York Genome Center, for example, is a joint venture among several New York-area research institutions: NYU, Columbia, Cold Spring Harbor Laboratories, to name a few.39 This arrangement allows researchers at these institutions to share a fleet of Illumina X Ten sequencers, the total cost of which—including operations—runs into the millions of US dollars.40 Where research funding is diminishing—as is sadly the case in much of the Anglophone world41—universities may foolishly hesitate to engage in similar cost-saving arrangements in the short-sighted hope of avoiding future patent lawsuits.42 One would hope that the CRISPR patent dispute teaches others that such myopia isn’t warranted.

#### Patent disputes create fears of litigation that deter genome research and investment

Reader 10/10 [(Ruth, a writer for fast company. She covers the intersection of health and technology) “2 women won the Nobel for CRISPR, but the battle for its patent rages on” Fast Company, 10/10/2020 <https://www.fastcompany.com/90561762/nobel-prize-jennifer-doudna-emmanuelle-charpentier-crispr-patent-lawsuit>] BC

CRISPR’S UNCERTAIN FUTURE

While the Nobel award certainly affixes Doudna and Charpentier’s place in history, the ongoing litigation continues to hang heavy over the development of CRISPR Cas-9’s editing capability. Some scientists feel that with so much public money involved in discoveries such as the ones around CRISPR Cas-9, no one should have a right to the intellectual property. This would keep the science open and allow others to innovate on top of it without the fear of litigation or the sometimes high costs of royalties. Meanwhile, investors, ever aware of the legal landscape, are looking to finance new biotechnology that doesn’t infringe on the existing CRISPR patents.

“We’re mindful that that litigation is going to have an impact on the freedom that our companies have to operate in,” says Paul Conley, a managing director at venture capital firm Paladin Capital Group. “We try to remain agnostic by finding the companies who are using CRISPR machinery—these nucleases—that definitely don’t tread on any of the IP that’s being litigated.”

That litigation hasn’t entirely stopped CRISPR exploration. In fact, a whole industry of apparatuses and chemicals has emerged to facilitate CRISPR gene edits. CRISPR Cas-9 is showing promising results as a treatment for rare diseases such as sickle cell anemia as well as an implement for biomanufacturing. But the litigation may be shifting gene-editing research. Like any technology, CRISPR Cas-9 is not perfect. It’s not as precise as some scientists would like, and it can have unanticipated effects outside of the desired outcome. Scientists who don’t already have a claim to the CRISPR Cas-9 system may be more inclined to seek out other gene-editing opportunities rather than improve Cas-9. Conley says scientists may be wary of pushing the technology ahead.

“It has absolutely put fear in the minds of many scientists who frankly could do great things for society,” says Conley. “They are living in terror of, well, if I go down this road a) am I going to be sued? And b) is there any commercial outlet where I’m going to have trouble raising money, because there’s fear and loathing around the CRISPR component”

Much of the new science surrounding CRISPR Cas-9 has come from scientists with a stake in the intellectual property. Last year, David Liu, a scientist at the Broad Institute and cofounder of gene-editing therapeutics company Editas Medicine, [published](https://www.nature.com/articles/d41586-019-03164-5) a way of making more precise edits with fewer unintended effects using a new process called prime editing. One of Doudna’s companies, Scribe Therapeutics, is engineering CRISPR molecules, rather than using the ones found in nature, in order to do away with the natural aspects that get in the way of putting it to good use as a targeted gene editor. The company just raised $20 million and [signed a deal](https://www.fiercebiotech.com/biotech/scribe-therapeutics-emerges-20m-biogen-pact-to-clear-crispr-hurdles) with pharmaceutical company Biogen to implement its technology.

#### Uncertainty about licensing ensures technology is not distributed or developed - smaller firms don’t know where they need to seek approval from

Sterlin 20 [(Ian, JD from the University of Michigan Law School, Executive Editor of the Michigan Technology Law Review) “The CRISPR War Drags On: How the Fight to Patent CRISPR-Cas9 Creates Uncertainty in the Biotechnology Sphere,” Michigan Technology Law Review, 3/2020] JL

On September 10, 2018, the Federal Circuit Court of Appeals (“Federal Circuit”) affirmed the ruling of the United States Patent Trial and Appeals Board (“the Board”) in *Regents of the University of California v. Broad Institute*, finding that there was no interference-in-fact between competing patents that claimed methods of using CRISPR-Cas9 to modify cellular DNA. Rather than settling the patentability issue, however, exhaustive litigation has continued, as both parties seek to protect the results obtained from costly research. Such protracted litigation has created significant uncertainty among members of the scientific, legal, and biotechnology communities as to the exact demarcation of patent ownership and may ultimately reduce the amount of innovation in CRISPR-based technologies and stifle developing industries.

Clustered Regularly Interspaced Short Palindromic Repeats (“CRISPR”) are a family of DNA sequences found naturally in bacteria that, when paired with guiding RNA sequences and CRISPR-associated proteins (Cas), can selectively modify an organism’s genetic material (genome) more effectively and cheaply than comparable gene-editing systems. Since the discovery of CRISPR’s gene-editing capacity by researchers at the University of California, the University of Vienna, and Emmanuelle Charpentier, innovators have applied CRISPR technology in diverse industries, including the medical, industrial, and agricultural sectors. Several thousand CRISPR-related patent applications have already been filed worldwide, with the majority being filed in the United States, China, and Europe.

Researchers at the University of California were the first to (“UC”) demonstrate that isolated CRISPR-Cas9 components could effectively function in an *in vitro* environment. UC subsequently filed a patent application in May 2012 broadly claiming a method to using CRISPR-Cas9 without referencing specific cellular environments. In December 2012, a research team led by Feng Zhang at the Broad Institute filed a patent application directed to a method of using CRISPR-Cas9 in mammal cells. UC unsuccessfully sought to invalidate Dr. Zhang’s patents in an interference proceeding in front of the Board. UC appealed the Board’s ruling to the Federal Circuit, arguing that the Board employed an improperly rigid obviousness test and that it erred in dismissing evidence that other researchers simultaneously applied CRISPR-Cas9 to non-bacterial (eukaryotic).

The Federal Circuit rejected UC’s arguments and affirmed the Board’s finding that substantial evidence indicated there was no reasonable expectation of success a person of ordinary skill in the relevant art (POSITA) could successfully apply CRISPR-Cas9 to eukaryotic genomes. The Federal Circuit approved of the wide range of evidence the Board used to make its determination, including expert testimony, evidence of past failures in the field, simultaneous invention, and statements by members of UC’s research team expressing doubt that CRISPR-Cas9 could be successfully implemented in eukaryotic systems. The Federal Circuit also rejected UC’s contention that evidence of simultaneous evidence alone sufficiently demonstrated an invention’s obviousness. While the fact that six independent research teams successfully applied CRISPR-Cas9 within months of its disclosure by UC was useful evidence in determining obviousness, the weight of such evidence must “be carefully considered in light of all the circumstances.”

It is unclear what the Federal Circuit’s decision means for the non-obviousness standard of CRISPR-related patents. Some observers have praised the ruling as affirming the Board’s comprehensive analysis of available factual evidence while noting that some evidence existed that could support a finding of obviousness. While the Federal Circuit rejected UC’s argument that simultaneous invention alone could not demonstrate a showing of obviousness, it was careful to state that such evidence had not demonstrated “a reasonable expectation of success given the ‘specific context of the art at the time.” This may suggest that evidence of simultaneous invention may gain greater significance in future decisions as advances are made in CRISPR technology. The Federal Circuit further clarified that its ruling determined that the competing sets of patent claims comprised distinct subject matter and did not rule on the validity of either parties’ claims.

The Federal Circuit’s holding has also generated a heated discussion outside of the legal field. Many members of the scientific community have criticized the decision, with some indicating that they believe the Board’s factual determination does not reflect the practices found within the field of molecular biology. The uncertainty resulting from the Federal Circuit’s decision is also reflected in the confusion among third party innovators regarding who they should seek a license from in order to commercially exploit existing CRISPR patents. This confusion is further compounded by the fact that the “surrogate companies” the Broad Institute and UC have created to manage the licensing of their patents grant differing levels of exclusivity when licensing their patents.

Further complicating the determination of patent rights in the foundational CRISPR-Cas9 patent is a lack of uniformity among the various national (and multinational) patent offices. Even before the Federal Circuit’s ruling, China’s State Intellectual Property Office (now renamed National Intellectual Property Administration or CNIPA) granted UC a patent for its CRISPR technology, and the European Patent Office (EPO) granted UC a patent for use CRISPR-Cas9 in both prokaryotic and eukaryotic organisms. The EPO subsequently rescinded a patent grant it had issued to the Broad Institute in 2015, finding that the prior art from UC’s patent demonstrated a lack of novelty for the invention. On January 17, 2020, the EPO’s Board of Appeal dismissed the Broad Institute’s appeal against the rescission, and in February, the Board of Appeal rejected the Broad Institute’s opposition proceeding against UC’s patent. Rather than creating a clear standard within Europe, however, the EPO’s rulings have resulted in greater uncertainty, with both the Broad Institute and UC, as well as other patentholders, having overlapping patent rights that may result in further litigation. In addition, several of the Broad Institute’s EPO patents for CRISPR remain valid and the CNIPA has granted three patents to the Broad Institute for CRISPR technologies.

Perhaps the most worrying development has been the renewal of UC and the Broad Institute’s legal battle in the United States. In June 2019, the Board filed documents to commence interference proceedings between the Broad Institute and UC’s patents that will address the question of priority. These new interference proceedings, which will examine who first invented the use of CRISPR-Cas9 in eukaryotic organisms, have already begun with both parties accusing the other of engaging in questionable legal conduct. Although some observers are optimistic that the new interference proceedings may induce the parties to reach a settlement, it is equally possible that the proceedings may result in a protracted legal battle and another appeal to the Federal Circuit. The protracted legal battles surrounding the UC and the Broad Institute’s CRISPR patents have created significant uncertainty as to the final determination of ownership and patentability. What is certain, however, is the need for greater clarity in patent rights in order to make researchers feel secure in developing further technological innovations using CRISPR-.

#### SCENARIO 1- DISEASE

#### CRISPR solves disease, but continued innovation is key

Thorne 20 [(Lucy, PhD, received a BSc. in Biochemistry from University of Leeds and a Ph.D. in Biological Sciences from University of Liverpool in the UK. She is currently working as a freelance consultant in Cambridge, UK writing CRISPR-related content for Biocompare.) “CRISPR-Cas Gene Editing: A New Weapon against Infectious Disease” Biocompare, 1/14/2020. <https://www.biocompare.com/Editorial-Articles/559757-CRISPR-Cas-Gene-Editing-A-New-Weapon-against-Infectious-Disease/>] BC

Infectious disease is a common cause of death worldwide, but the rise of antibiotic-resistant bacterial strains and lack of effective antiviral treatments means a potential future risk of increased mortality and global economic burden due to untreatable infections. This article discusses how CRISPR-Cas gene-editing technology is helping in the fight against increasingly resistant bacterial infections and rapidly mutating viruses—from facilitating a better understand of host-pathogen interactions and improving diagnosis, to potentially providing a new way to treat infectious disease.

The CRISPR revolution

The CRISPR locus (short for clustered regularly interspersed short palindromic repeats) was first discovered in E.coli in 1987 and found to be the basis of a bacterial adaptive immune system, providing prokaryotes with protection against foreign genetic material.1 The CRISPR-Cas system has since been repurposed into a powerful but relatively simple programmable gene-editing technology. A short single-guide RNA molecule (sgRNA) guides the Cas9 endonuclease to the target site, where a double-strand break is introduced. This activates intrinsic cellular DNA repair pathways, either the non-homologous end joining (NHEJ) pathway that results in a disabling deletion of the target gene, or homologous repair (HR) that allows the integration of a donor sequence at the target locus. As well as gene knockout and targeted changes to the genetic sequence, gene expression can be regulated. Other modifications at the target site are also possible with the use of a catalytically inactive version of Cas9 (dCas9)—the expanded CRISPR toolkit also includes modulation of gene expression (CRISPRi and CRISPRa) and base editing.

Since the first CRISPR gene-editing experiments were demonstrated in 2012, the CRISPR-Cas9 technology has exploded into the biological sciences and been rapidly adopted by the scientific community. CRISPR has already shown promise in the prevention of malaria, tuberculosis, and herpes simplex virus.2 Below, we highlight a few ways in which CRISPR has been recently applied to improving our understanding, treatment, and ongoing diagnosis of infectious disease.

Functional genomics with CRISPR to determine new antimicrobial targets

There is currently a distinct lack of new antibiotics and antiviral drugs making it to the clinic. Understanding host-pathogen mechanisms that govern how microbes induce pathogenesis is crucial for identifying new targets for rapid drug discovery and vaccine development. Soon after its debut, CRISPR-Cas9 was applied to functional genomic screening. Using a pooled sgRNA library workflow, CRISPR-Cas9 was successfully used at scale to enable high-throughput, genome-wide loss of function studies. CRISPR-Cas9 genome-wide screening has since been employed in a variety of pathogens to determine the molecular pathways that drive pathogenesis. These include identifying how the α-hemolysin virulence factor S.aureus causes cytotoxicity and genes involved in host-cell dependencies from Zika virus.3,4

CRISPR-Cas9 as a next-generation diagnostic for antimicrobial-resistance genes

Since the discovery of penicillin in 1928, antibiotics have been the main treatment against bacterial infections, reducing mortality and significantly improving life expectancy the world over. But the ability of microbes to rapidly mutate and share genetic information, as well as the overprescription of antibiotics, has led to the emergence of superbugs—strains that are resistant to existing treatments. According to the UN, antibiotic resistance is thought to cause around 700,000 deaths per year, which could rise to 10 million by 2050.

Determining whether genes responsible for antimicrobial resistance (AMR) are present is crucial when formulating an optimal treatment strategy to limit the spread of drug resistance. Unfortunately, real-time metagenomic analysis is hampered by the low abundance of resistant pathogens against a high background. Recent work from the Crawford lab at the University of California, San Francisco used CRISPR to develop a novel NGS-targeted enrichment system called FLASH (finding low abundance sequences by hybridization), which they use as a diagnostic.5 By using sgRNA to guide Cas9 to AMR genes, those sequences are cleaved ready for next-generation sequencing. FLASH enables amplification of AMR targets and high levels of multiplexing and was shown to successfully identify AMR genes in patient samples, including those infected with pneumonia-causing bacteria and Plasmodium falciparum, the malaria parasite.

Selectively controlling the microbiome

The human microbiome is a complex ecosystem of species that all play a role in health —but treatment with broad-spectrum antibiotics to destroy pathogens also kills the “good” bacteria, upsetting the delicate balance and the positive symbiotic relationships that help control pathogens. This blunt instrument also provides a selective pressure that can lead to the further development of antibiotic-resistant strains.

In a recent Nature Communications paper, Hamilton et al used CRISPR-Cas9 to selectively target and kill Salmonella enterica but leave other bacteria species in a co-culture unharmed.6 Their work utilizes a conjugative plasmid to put the delivery machinery together with the necessary Cas9 molecules in a cis-conjugative system to selectively target essential genes in S. enterica cells and destroy them. The authors also suggest their new delivery system could be beneficial in controlling microbial imbalances on biofilms with potential applications in medicine, healthcare, and industrial processes—for example in treating Clostridium difficile, a hospital-acquired infection that is placing an increasing economic burden on healthcare systems worldwide.

CRISPR: as nature intended?

In nature, CRISPR is an endogenous bacterial system used to protect from foreign genetic material, so it makes sense that it is now being used in medicine against the bacteria themselves to fight infectious disease. And not only bacteria—recent work from the Broad Institute used the Cas13 protein from the CRISPR system to selectively target and destroy single-stranded RNA viruses, including Influenza A, significantly and rapidly reducing viral load and infectiousness.7

The programmable nature of the CRISPR gene-editing system means that as microbes continue to evolve and mutate, the CRISPR machinery can be quickly altered to destroy the new target as an antimicrobial drug, or detect it as a diagnostic. Work will now move onto demonstrate that these CRISPR-based antimicrobial applications can work in the clinic and help combat the growing specter of antimicrobial resistance and infectious disease.

#### Extinction – defense is wrong

Piers Millett 17, Consultant for the World Health Organization, PhD in International Relations and Affairs, University of Bradford, Andrew Snyder-Beattie, “Existential Risk and Cost-Effective Biosecurity”, Health Security, Vol 15(4), http://online.liebertpub.com/doi/pdfplus/10.1089/hs.2017.0028

Historically, disease events have been responsible for the greatest death tolls on humanity. The 1918 flu was responsible for more than 50 million deaths,1 while smallpox killed perhaps 10 times that many in the 20th century alone.2 The Black Death was responsible for killing over 25% of the European population,3 while other pandemics, such as the plague of Justinian, are thought to have killed 25 million in the 6th century—constituting over 10% of the world’s population at the time.4 It is an open question whether a future pandemic could result in outright human extinction or the irreversible collapse of civilization.

A skeptic would have many good reasons to think that existential risk from disease is unlikely. Such a disease would need to spread worldwide to remote populations, overcome rare genetic resistances, and evade detection, cures, and countermeasures. Even evolution itself may work in humanity’s favor: Virulence and transmission is often a trade-off, and so evolutionary pressures could push against maximally lethal wild-type pathogens.5,6

While these arguments point to a very small risk of human extinction, they do not rule the possibility out entirely. Although rare, there are recorded instances of species going extinct due to disease—primarily in amphibians, but also in 1 mammalian species of rat on Christmas Island.7,8 There are also historical examples of large human populations being almost entirely wiped out by disease, especially when multiple diseases were simultaneously introduced into a population without immunity. The most striking examples of total population collapse include native American tribes exposed to European diseases, such as the Massachusett (86% loss of population), Quiripi-Unquachog (95% loss of population), and theWestern Abenaki (which suffered a staggering 98% loss of population).

In the modern context, no single disease currently exists that combines the worst-case levels of transmissibility, lethality, resistance to countermeasures, and global reach. But many diseases are proof of principle that each worst-case attribute can be realized independently. For example, some diseases exhibit nearly a 100% case fatality ratio in the absence of treatment, such as rabies or septicemic plague. Other diseases have a track record of spreading to virtually every human community worldwide, such as the 1918 flu,10 and seroprevalence studies indicate that other pathogens, such as chickenpox and HSV-1, can successfully reach over 95% of a population.11,12 Under optimal virulence theory, natural evolution would be an unlikely source for pathogens with the highest possible levels of transmissibility, virulence, and global reach. But advances in biotechnology might allow the creation of diseases that combine such traits. Recent controversy has already emerged over a number of scientific experiments that resulted in viruses with enhanced transmissibility, lethality, and/or the ability to overcome therapeutics.13-17 Other experiments demonstrated that mousepox could be modified to have a 100% case fatality rate and render a vaccine ineffective.18 In addition to transmissibility and lethality, studies have shown that other disease traits, such as incubation time, environmental survival, and available vectors, could be modified as well.19-2

#### SCENARIO 2- CLIMATE CHANGE

#### CRISPR solves warming

Labant 20 [(MaryAnn, Author at GEN) “CRISPR Targets Climate Change” Genetic Engineering and Biotechnology News, 10/27/20. https://www.genengnews.com/insights/crispr-targets-climate-change/] RR

The big climate change conundrum is how to provide the necessary calories, nutrition, and living materials to an increasing population without destroying the planet that we live on. According to the United Nations, the world’s population is expected to increase from 7.7 billion in 2020 to 9.7 billion in 2050 and could peak at nearly 11 billion around 2100.

“Climate change needs to be addressed with a sense of urgency. We can start to change the world today with contributions from different approaches and fields, encompassing various technologies, and scientific communities,” says Rodolphe Barrangou, PhD, distinguished professor & university faculty scholar, department of food, bioprocessing and nutrition sciences, North Carolina State University.

The UN’s Intergovernmental Panel on Climate Change (IPCC) special report on land takes on the scope of the 197 million square miles of land on Earth and two extremely complex questions about how land use contributes to climate change and how climate change affects land.

The report’s conclusions lay out a crucial paradox. Humans have harnessed land to develop into a highly successful species but in doing so have wreaked havoc. The destructive patterns of land use, in particular agriculture, deforestation, and development of wetlands, now contribute 23 percent of all human-caused greenhouse gas emissions.1

Genome editing may be one of the solutions to address climate change. A September 2020 report by the Information Technology & Innovation Foundation (ITIF), Gene Editing for the Climate: Biological Solutions for Curbing Greenhouse Emissions, emphasizes that gene-editing technology could be used to develop clean energy and climate solutions that policymakers have to date under-emphasized.2

Healthier forests

Trees are excellent at capturing and sequestering carbon. To be more sustainable, healthier, climate- and disease-resistant, tree breeders need to adopt the best technologies available. CRISPR has tremendous power and promise and is already in use on a small scale at an early research stage to improve genotypes and phenotypes of trees of interest across the world.

“Many forests are commercially exploited for timber, chemicals, and fiber,” says Barrangou. “Much like crops, some commercial staple species are very important, such as pine, poplar, and eucalyptus, but natural biodiversity exists in forests; therefore, arguably all tree species have their role to play across the tree of life given the diverse geographies and environmental conditions where forests occur and thrive. Forest stewardship and management is important and critical, but only part of the picture. Building better forests can be beneficial to so many. I urge the world to be mindful of and more committed to forests. “

To illustrate the fragility of trees, a tree viral pandemic, like Citrus Tristeza Virus (CTV), or the rise of bacterial pathogens such as Citrus Greening (also known as Huanglongbing HLB-disease) can put an entire species at risk. Using classical techniques, breeding a tree can take decades; laboratory-based molecular techniques can reduce that time to 1–2 years along with other required resources. Recently, powerful CRISPR-based technologies grant the ability to accelerate and precisely manage the process by making informed genetic alterations to create beneficial outcomes.

Barrangou adds that CRISPR has a lot to offer forestry but new trails will need to be blazed on this steep and less traveled road that has not only different challenges than crops but also is decades behind in terms of adoption of molecular techniques. Trees are very complex from a genetics perspective with an average genome 10x the size of the human and much less understood. He believes CRISPR offers hope for this sizeable (both literally and figuratively), difficult problem but just as important is a thoroughly thought out implementation plan.

Refining agriculture

“New green products are going to be dependent on available gene-editing tools, ranging from GMO techniques to CRISPR, TALENs, and other technologies. The technology used will depend on the goal, but, in reality, all available means need to be utilized,” says OIiver Peoples, PhD, CEO, Yield10 Bioscience.

One approach to reducing climate change is better utilization of the land to mitigate food waste, which produces 1.9B tons of CO2 each year. At least one third of the annual global food production is wasted due to a variety of reasons, including disease and insects.2 The IPCC report states with high confidence that policies that operate across the food system, including those that reduce food loss and waste and influence dietary choices, enable more sustainable land-use management, enhanced food security and low emissions trajectories.1

The original GMO pesticide-producing applications focused on starting to resolve a part of the issue with good results. On average, GMO use has reduced chemical pesticide use by 37% and increased crop yields by 22%.2

Despite ongoing debate about the use of this technology, of note is a 2016 study by the National Academies of Science, Engineering, and Medicine confirming that there are no safety concerns with GMOs.

More recently, CRISPR and the newer gene-editing applications are also being used to address food issues by reducing apple or potato browning and tomato softening to extend the shelf life of produce. In addition, disease-resistant fruits are under development, such as the Panama disease resistant Cavendish bananas that are being field tested by Tropic Biosciences.

Furthermore, many companies are focusing on extending the nutritional value of food by adding more protein to soy and other staple crops, and making oils, including soybean and canola, healthier. For example, Calyxt used TALENs to develop Calyno, high oleic soybean oil, the first gene-edited product on the market in the US. Another firm of note, Pairwise Plants, is working to develop new and delicious types of leafy greens, berries, and cherries, along with other efforts in staple crops.

The role of technology and its impact on agriculture is unprecedented. According to Peoples, it is important to start by looking at fundamentals in a scientific way and first ask whether a change makes sense; if it has a meaningful impact and is sustainable.

“We thought we had an entire revolution with the use of GMO technologies, which turned out to be one of the greenest developments in agriculture in the last hundred years,” he continues. “Now we have more techniques, including CRISPR genome editing, to manipulate the genome; if you are serious about mitigating climate change you need to access the entire toolbox. This century is going to be about biology, We have to let nature lead the way to find solutions and the most efficient path is using genes to rebalance the agricultural systems while also meeting the growing demand, a difficult paradigm.”

The real problem is identification of the bottlenecks and genes; plants are very complex systems.

For example, photosynthesis is an elegant and efficient tool to help reduce atmospheric levels of CO2 because it already functions as a negative emission technology.2 In field studies, Yield10 Bioscience has improved photosynthesis in some plant species by making reactions more efficient to produce a higher output by tweaking gene regulators and shifting carbon flows through the plant. For example, their C3004 trait gene promotes an increase in photosynthesis in Camelina and canola.

Camelina is a crop with a 100-day growing cycle. As a winter cover crop it is a sustainable climate change effort because it creates a cash crop for farmers incentivizing them to plant it. Cover crops are intended to prevent soil erosion and run off of nitrates and nutrients into water but if they do not generate revenues they are not used as frequently as they could be.

Using CRISPR, one of Yield10 Bioscience’s areas of focus has been on increasing the amount of edible oil in Camelina seeds since oil is the economic driver. Oil is extracted from the seed and the left-over protein fractions are used as animal feed. Field tests have been performed with a triple genome edit and will continue with additional gene edits. Note that CRISPR is not used to introduce foreign genes into a plant; it is used to edit existing bases pairs or genes to introduce new traits.

Another aspect of the food chain that could be harnessed to positively impact climate change is food packaging. Produce and other food companies that use but do not produce plastics are looking for sustainable alternatives, which are not trivial to develop. A cost effective solution to this problem that does not produce more emissions is a huge endeavor. Much as some would like to eliminate plastics, the COVID pandemic has demonstrated they are a necessity.

Plants are the only way to make a biodegradable biomaterial at the scale and cost to compete with petroleum-based products. Yield10 Bioscience’s ultimate goal for Camelina is to engineer the plant to produce a third product, a bioplastic. In order for the species to produce a bioplastic, insertion of microbial genes is necessary, and thus would evolve the CRISPR-edited Camelina into a GMO plant. The oil, protein, and bioplastic material would come from processing the seed and provide additional value to farmers to use it as a cover crop.

If Camelina can be used to replace polystyrene, carbon emissions could potentially be significantly reduced while simultaneously adding the other benefits of producing edible oil and protein. From a climate change and sustainability point of view, multi-product approaches from one plant have the potential to be game changers.

“The green future is going to be a gene-based production system; it has to be. We believe genome editing is an important tool, and CRISPR may allow you to get started but you cannot meet global demand for food production and have a meaningful impact on climate change without using all the available methods at your disposal,” says Peoples.

The ITIF report concurs and strongly encourages governments to increase investments and improve coordination of R&D and expand incentives for adopting gene-editing technology to accelerate the development and deployment of biologically-driven clean energy and climate solutions. They believe that gene editing can increase photosynthesis efficiency, reduce methane emissions from cattle and rice patties, optimize biofuel crops, and solve many other climate challenges.2

**Warming causes extinction**

**Ramanathan et al. 17** [Veerabhadran Ramanathan is Victor Alderson Professor of Applied Ocean Sciences and director of the Center for Atmospheric Sciences at the Scripps Institution of Oceanography, University of California, San Diego, Dr. William Collins is an internationally recognized expert in climate modeling and climate change science. He is the Director of the Climate and Ecosystem Sciences Division (CESD) for the Earth and Environmental Sciences Area (EESA) at the Lawrence Berkeley National Laboratory (LBNL), Prof. Dr Mark Lawrence, Ph.D. is scientific director at the Institute for Advanced Sustainability Studies (IASS) in Potsdam, Örjan Gustafsson is a Professor in the Department of Environmental Science and Analytic Chemistry at Stockholm University, Shichang Kang is Professor, Cold and Arid Regions Environmental and Engineering Research Institute, Chinese Academy of Sciences (CAS); CAS Center for Excellence in Tibetan Plateau Earth Sciences, and Molina, M.J., Zaelke, D., Borgford-Parnell, N., Xu, Y., Alex, K., Auffhammer, M., Bledsoe, P., Croes, B., Forman, F., Haines, A., Harnish, R., Jacobson, M.Z., Lawrence, M., Leloup, D., Lenton, T., Morehouse, T., Munk, W., Picolotti, R., Prather, K., Raga, G., Rignot, E., Shindell, D., Singh, A.K., Steiner, A., Thiemens, M., Titley, D.W., Tucker, M.E., Tripathi, S., & Victor, D., authors come from the following 9 countries - US, Switzerland, Sweden, UK, China, Germany, Australia, Mexico, India, “Well Under 2 Degrees Celsius: Fast Action Policies to Protect People and the Planet from Extreme Climate Change,” Report of the Committee to Prevent Extreme Climate Change, September 2017, http://www.igsd.org/wp-content/uploads/2017/09/Well-Under-2-Degrees-Celsius-Report-2017.pdf] TDI

**Climate change is becoming an existential threat with warming in excess of 2°C within the next three decades and 4°C to 6°C within the next several decades. Warming of such magnitudes will expose as many as 75% of the world’s population to deadly heat stress in addition to disrupting the climate and weather worldwide. Climate change is an urgent problem requiring urgent solutions**. This paper lays out urgent and **practical solutions that are ready for implementation now, will deliver benefits in the next few critical decades**, and places the world on a path to achieving the longterm targets of the Paris Agreement and near-term sustainable development goals. The approach consists of four building blocks and 3 levers to implement ten scalable solutions described in this report by a team of climate scientists, policy makers, social and behavioral scientists, political scientists, legal experts, diplomats, and military experts from around the world. These solutions will enable society to decarbonize the global energy system by 2050 through efficiency and renewables, drastically reduce short-lived climate pollutants, and stabilize the climate well below 2°C both in the near term (before 2050) and in the long term (post 2050). It will also reduce premature mortalities by tens of millions by 2050. As an insurance against policy lapses, mitigation delays and faster than projected climate changes, the solutions include an Atmospheric Carbon Extraction lever to remove CO2 from the air. The amount of CO2 that must be removed ranges from negligible, if the emissions of CO2 from the energy system and SLCPs start to decrease by 2020 and carbon neutrality is achieved by 2050, to a staggering one trillion tons if the carbon lever is not pulled and emissions of climate pollutants continue to increase until 2030.

There are numerous living laboratories including 53 cities, many universities around the world, the state of California, and the nation of Sweden, who have embarked on a carbon neutral pathway. These laboratories have already created 8 million jobs in the clean energy industry; they have also shown that **emissions of greenhouse gases and air pollutants can be decoupled from economic growth**. Another favorable sign is that **growth rates of worldwide carbon emissions have reduced from 2.9% per year during the first decade of this century to 1.3% from 2011 to 2014 and near zero growth rates during the last few years. The carbon emission curve is bending, but we have a long way to go and very little time for achieving carbon neutrality**. We need institutions and enterprises that can accelerate this bending by scaling-up the solutions that are being proven in the living laboratories. We have less than a decade to put these solutions in place around the world to preserve nature and our quality of life for generations to come. The time is now.

The Paris Agreement is an historic achievement. For the first time, effectively all nations have committed to limiting their greenhouse gas emissions and taking other actions to limit global temperature change. Specifically, 197 nations agreed to hold “the increase in the global average temperature to well below 2°C above pre-industrial levels and pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels,” and achieve carbon neutrality in the second half of this century.

**The climate has already warmed by 1°C. The problem is running ahead of us, and under current trends we will likely reach 1.5°C in the next fifteen years and surpass the 2°C guardrail by mid-century with a 50% probability of reaching 4°C by end of century**. Warming in excess of 3°C is likely to be a global catastrophe for three major reasons:

• **Warming in the range of 3°C to 5°C is suggested as the threshold for several tipping points in the physical and geochemical systems; a warming of about 3°C has a probability of over 40% to cross over multiple tipping points, while a warming close to 5°C increases it to nearly 90%, compared with a baseline warming of less than 1.5°C, which has only just over a 10% probability of exceeding any tipping point.**

**• Health effects of such warming are emerging as a major if not dominant source of concern. Warming of 4°C or more will expose more than 70% of the population, i.e. about 7 billion by the end of the century, to deadly heat stress and expose about 2.4 billion to vector borne diseases such as Dengue, Chikengunya, and Zika virus among others**. Ecologists and paleontologists have proposed that warming in excess of 3°C, accompanied by increased acidity of the oceans by the buildup of CO2 , can become a major causal factor for exposing more than 50% of all species to extinction. 20% of species are in danger of extinction now due to population, habitat destruction, and climate change.

The good news is that **there may still be time to avert such catastrophic changes**. The Paris Agreement and **supporting climate policies must be strengthened substantially within the next five years to bend the emissions curve down faster, stabilize climate, and prevent catastrophic warming**. To the extent those efforts fall short, societies and **ecosystems will be forced to contend with substantial needs for adaptation—a burden that will fall disproportionately on the poorest three billion who are least responsible for causing the climate change problem.**

Here we propose a policy roadmap with a realistic and reasonable chance of limiting global temperature to safe levels and preventing unmanageable climate change—an outline of specific science-based policy pathways that serve as the building blocks for a three-lever strategy that could limit warming to well under 2°C. The projections and the emission pathways proposed in this summary are based on a combination of published recommendations and new model simulations conducted by the authors of this study (see Figure 2). We have framed the plan in terms of four building blocks and three levers, which are implemented through 10 solutions. The first building block would be fully implementing the nationally determined mitigation pledges under the Paris Agreement of the UN Framework Convention on Climate Change (UNFCCC). In addition, several sister agreements that provide targeted and efficient mitigation must be strengthened. Sister agreements include the Kigali Amendment to the Montreal Protocol to phase down HFCs, efforts to address aviation emissions through the International Civil Aviation Organization (ICAO), maritime black carbon emissions through the International Maritime Organization (IMO), and the commitment by the eight countries of the Arctic Council to reduce black carbon emissions by up to 33%. There are many other complementary processes that have drawn attention to specific actions on climate change, such as the Group of 20 (G20), which has emphasized reform of fossil fuel subsidies, and the Climate and Clean Air Coalition (CCAC). HFC measures, for example, can avoid as much as 0.5°C of warming by 2100 through the mandatory global phasedown of HFC refrigerants within the next few decades, and substantially more through parallel efforts to improve energy efficiency of air conditioners and other cooling equipment potentially doubling this climate benefit.

For the second building block, numerous subnational and city scale climate action plans have to be scaled up. One prominent example is California’s Under 2 Coalition signed by over 177 jurisdictions from 37 countries in six continents covering a third of world economy. The goal of this Memorandum of Understanding is to catalyze efforts in many jurisdictions that are comparable with California’s target of 40% reductions in CO2 emissions by 2030 and 80% reductions by 2050—emission cuts that, if achieved globally, would be consistent with stopping warming at about 2°C above pre-industrial levels. Another prominent example is the climate action plans by over 52 cities and 65 businesses around the world aiming to cut emissions by 30% by 2030 and 80% to 100% by 2050. There are concerns that the carbon neutral goal will hinder economic progress; however, real world examples from California and Sweden since 2005 offer evidence that economic growth can be decoupled from carbon emissions and the data for CO2 emissions and GDP reveal that growth in fact prospers with a green economy.

The third building block consists of two levers that we need to pull as hard as we can: one for drastically reducing emissions of short-lived climate pollutants (SLCPs) beginning now and completing by 2030, and the other for decarbonizing the global energy system by 2050 through efficiency and renewables. Pulling both levers simultaneously can keep global temperature rise below 2°C through the end of the century. If we bend the CO2 emissions curve through decarbonization of the energy system such that global emissions peak in 2020 and decrease steadily thereafter until reaching zero in 2050, there is less than a 20% probability of exceeding 2°C. This call for bending the CO2 curve by 2020 is one key way in which this report’s proposal differs from the Paris Agreement and it is perhaps the most difficult task of all those envisioned here. Many cities and jurisdictions are already on this pathway, thus demonstrating its scalability. Achieving carbon neutrality and reducing emissions of SLCPs would also drastically reduce air pollution globally, including all major cities, thus saving millions of lives and over 100 million tons of crops lost to air pollution each year. In addition, these steps would provide clean energy access to the world’s poorest three billion who are still forced to resort to 18th century technologies to meet basic needs such as cooking. For the fourth and the final building block, we are adding a third lever, ACE (Atmospheric Carbon Extraction, also known as Carbon Dioxide Removal, or “CDR”). This lever is added as an insurance against surprises (due to policy lapses, mitigation delays, or non-linear climate changes) and would require development of scalable measures for removing the CO2 already in the atmosphere. The amount of CO2 that must be removed will range from negligible, if the emissions of CO2 from the energy system and SLCPs start to decrease by 2020 and carbon neutrality is achieved by 2050, to a staggering one trillion tons, if CO2 emissions continue to increase until 2030, and the carbon lever is not pulled until after 2030. This issue is raised because the NDCs (Nationally Determined Contributions) accompanying the Paris Agreement would allow CO2 emissions to increase until 2030. We call on economists and experts in political and administrative systems to assess the feasibility and cost-effectiveness of reducing carbon and SLCPs emissions beginning in 2020 compared with delaying it by ten years and then being forced to pull the third lever to extract one trillion tons of CO2

The fast mitigation plan of requiring emissions reductions to begin by 2020, which means that many countries need to cut now, is urgently needed to limit the warming to well under 2°C. Climate change is not a linear problem. Instead, we are facing non-linear climate tipping points that can lead to self-reinforcing and cascading climate change impacts. Tipping points and selfreinforcing feedbacks are wild cards that are more likely with increased temperatures, and many of the potential abrupt climate shifts could happen as warming goes from 1.5°C in 15 years to 2°C by 2050, with the potential to push us well beyond the Paris Agreement goals.

Where Do We Go from Here?

**A massive effort will be needed to stop warming at 2°C, and time is of the essence. With unchecked business-as-usual emissions, global warming has a 50% likelihood of exceeding 4ºC and a 5% probability of exceeding 6ºC in this century, raising existential questions for most, but especially the poorest three billion people. A 4ºC warming is likely to expose as many as 75% of the global population to deadly heat.** Dangerous to catastrophic impacts on the health of people including generations yet to be born, on the health of ecosystems, and on species extinction have emerged as major justifications for mitigating climate change well below 2ºC, although we must recognize that the uncertainties intrinsic in climate and social systems make it hard to pin down exactly the level of warming that will trigger possibly catastrophic impacts. To avoid these consequences, we must act now, and we must act fast and effectively. This report sets out a specific plan for reducing climate change in both the near- and long-term. With aggressive urgent actions, we can protect ourselves. Acting quickly to prevent catastrophic climate change by decarbonization will save millions of lives, trillions of dollars in economic costs, and massive suffering and dislocation to people around the world. This is a global security imperative, as it can avoid the migration and destabilization of entire societies and countries and reduce the likelihood of environmentally driven civil wars and other conflicts.

Staying well under 2°C will require a concerted global effort. We must address everything from our energy systems to our personal choices to reduce emissions to the greatest extent possible. We must redouble our efforts to invent, test, and perfect systems of governance so that the large measure of international cooperation needed to achieve these goals can be realized in practice. The health of people for generations to come and the health of ecosystems crucially depend on an energy revolution beginning now that will take us away from fossil fuels and toward the clean renewable energy sources of the future. It will be nearly impossible to obtain other critical social goals, including for example the UN agenda 2030 with the Sustainable Development Goals, if we do not make immediate and profound progress stabilizing climate, as we are outlining here.

1. The Building Blocks Approach The 2015 Paris Agreement, which went into effect November 2016, is a remarkable, historic achievement. For the frst time, essentially all nations have committed to limit their greenhouse gas emissions and take other actions to limit global temperature and adapt to unavoidable climate change. Nations agreed to hold “the increase in the global average temperature to well below 2°C above pre-industrial levels and pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels” and “achieve a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century” (UNFCCC, 2015). Nevertheless, the initial Paris Agreement has to be strengthened substantially within fve years if we are to prevent catastrophic warming; **current pledges place the world on track for up to 3.4°C by 2100 (UNEP, 2016b). Until now, no specifc policy roadmap exists that provides a realistic and reasonable chance of limiting global temperatures to safe levels and preventing unmanageable climate change**. This report is our attempt to provide such a plan— an outline of specifc solutions that serve as the building blocks for a comprehensive strategy for limiting the warming to well under 2°C and avoiding dangerous climate change (Figure 1). The frst building block is the full implementation of the nationally determined mitigation pledges under the Paris Agreement of the UN Framework Convention on Climate Change (UNFCCC) and strengthening global sister agreements, such as the Kigali Amendment to the Montreal Protocol to phase down HFCs, which can provide additional targeted, fast action mitigation at scale. For the second building block, numerous sub-national and city scale climate action plans have to be scaled up such as California’s Under 2 Coalition signed by 177 jurisdictions from 37 countries on six continents. The third building block is targeted measures to reduce emissions of shortlived climate pollutants (SLCPs), beginning now and fully implemented by 2030, along with major measures to fully decarbonize the global economy, causing the overall emissions growth rate to stop in 2020-2030 and reach carbon neutrality by 2050. Such a deep decarbonization would require an energy revolution similar to the Industrial Revolution that was based on fossil fuels. The fnal building block includes scalable and reversible carbon dioxide (CO2 ) removal measures, which can begin removing CO2 already emitted into the atmosphere. Such a plan is urgently needed. Climate change is not a linear problem. Instead, climate tipping points can lead to self-reinforcing, cascading climate change impacts (Lenton et al., 2008). Tipping points are more likely with increased temperatures, and many of the potential abrupt climate shifts could happen as warming goes from 1.5°C to 2°C, with the potential to push us well beyond the Paris Agreement goals (Drijfhout et al., 2015). In order to avoid dangerous climate change, we must address these concerns. **We must act now, and we must act fast. Reduction of SLCPs will result in fast, near-term reductions in warming, while present-day reductions of CO2 will result in long-term climate benefts**. This two-lever approach—aggressively cutting both SLCPs and CO2 –-will slow warming in the coming decades when it is most crucial to avoid impacts from climate change as well as maintain a safe climate many decades from now. To achieve the nearterm goals, we have outlined solutions to be implemented immediately. These solutions to bend down the rising emissions curve and thus bend the warming trajectory curve follow a 2015 assessment by the University of California under its Carbon Neutrality Initiative (Ramanathan et al., 2016). The solutions are clustered into categories of social transformation, governance improvement, market- and regulation-based solutions, technological innovation and transformation, and natural and ecosystem management. Additionally, we need to intensely investigate and pursue a third lever—ACE (Atmospheric Carbon Extraction). While many potential technologies exist, we do not know the extent to which they could be scaled up to remove the requisite amount of carbon from the atmosphere in order to achieve the Paris Agreement goals, and any delay in mitigation will demand increasing reliance on these technologies. Yet, there is still hope. Humanity can come together, as we have done in the past, to collaborate towards a common goal. We have no choice but to tackle the challenge of climate change. We only have the choice of when and how: **either now, through the ambitious plan outlined here, or later, through radical adaptation and societal transformations in response to an ever-deteriorating climate system that will unleash devastating impacts—some of which may be beyond our capacity to fully adapt to or reverse for thousands of years.**

2. Major Climate Disruptions: How Soon and How Fast? “Without adequate mitigation and adaptation, climate change poses unacceptable risks to global public health.” (WHO, 2016)

The planet has already witnessed nearly 1°C of warming, and another 0.6°C of additional warming is currently stored in the ocean to be released over the next two to four decades, if climate warming emissions are not radically reduced during that time (IPCC, 2013). The impacts of this warming on extreme weather, droughts, and foods are being felt by society worldwide to the extent that many think of this no longer as climate change but as climate disruption. Consider the business as usual scenario:

15 years from now: In 15 years, planetary warming will reach 1.5°C above pre-industrial global mean temperature (Ramanathan and Xu, 2010; Shindell et al., 2012). This exceeds the 0.5°C to 1°C of warming during the Eemian period, 115,000– 130,000 years ago, when sea-levels reached 6-9 meters (20-30 feet) higher than today (Hansen et al., 2016b). The impacts of this warming will affect us all yet will disproportionately affect the Earth’s poorest three billion people, who are primarily subsistence farmers that still rely on 18th century technologies and have the least capacity to adapt (IPCC, 2014a; Dasgupta et al., 2015). They thus may be forced to resort to mass migration into city slums and push across international borders (U.S. DOD, 2015). The existential fate of lowlying small islands and coastal communities will also need to be addressed, as they are primarily vulnerable to sea-level rise, diminishing freshwater resources, and more intense storms. In addition, many depend on fsheries for protein, and these are likely to be affected by ocean acidifcation and climate change. Climate injustice could start causing visible regional and international conficts. All of this will be exacerbated as the risk of passing tipping points increases (Lenton et al., 2008).

30 years from now: By mid-century, warming is expected to exceed 2°C, which would be unprecedented with respect to historical records of at least the last one million years (IPCC, 2014c). Such a warming through this century could result in sea-level rise of as much as 2 meters by 2100, with greater sea-level rise to follow. A group of tipping points are clustered between 1.5°C and 2°C (Figure 2) (Drijfhout et al., 2015). The melting of most mountain glaciers, including those in the Tibetan-Himalayas, combined with mega-droughts, heat waves, storms, and foods, would adversely affect nearly everyone on the planet.

80 years from now: In 80 years, warming is expected to exceed 4°C, increasing the likelihood of irreversible and catastrophic change (World Bank, 2013b). 4ºC warming is likely to expose as much as 75% of the global population to deadly heat (Mora et al., 2017). The 2°C and 4°C values quoted above and in other reports, however, are merely the central values with a 50% probability of occurrence (Ramanathan and Feng, 2008). There is a 5% probability the warming could be as high as 6°C due to uncertainties in the magnitude of amplifying feedbacks (see Section 4). This in turn could lead to major disruptions to natural and social systems, threatening food security, water security, and national security and fundamentally affecting the great majority of the projected 11.2 billion inhabitants of the planet in 2100 (UN DESA, 2015).

3. What Are the Wild Cards for Climate Disruption? Increasing the concentrations of greenhouse gases in the atmosphere increases radiative forcing (the difference between the amount of energy entering the atmosphere and leaving) and thus increases the global temperature (IPCC, 2013). However, climate wild cards exist that can alter the linear connection with warming and anthropogenic emissions by triggering abrupt changes in the climate (Lenton et al., 2008). Some of these wild cards have not been thoroughly captured by the models that policymakers rely on the most. These abrupt shifts are irreversible on a human time scale (<100 years) and will create a notable disruption to the climate system, condemning the world to warming beyond that which we have previously projected. These climate disruptions would divert resources from needed mitigation and upset mitigation strategies that we have already put in place.

1. Unmasking Aerosol Cooling: The frst such wild card is the unmasking of an estimated 0.7°C (with an uncertainty range of 0.3°C to 1.2°C) of the warming in addition to mitigating other aerosol effects such as disrupting rainfall patterns, by reducing emissions of aerosols such as sulfates and nitrates as part of air pollution regulations (Wigley, 1991; Ramanathan and Feng, 2008). Aerosol air pollution is a major health hazard with massive costs to public health and society, including contributing to about 7 million deaths (from household and ambient exposure) each year (WHO, 2014). While some aerosols, such as black carbon and brown carbon, strongly absorb sunlight and warm the climate, others refect sunlight back into space, which cools the climate (Ramanathan and Carmichael, 2008). The net impact of all manmade aerosols is negative, meaning that about 30% of the warming from greenhouse gases is being masked by co-emitted air pollution particles (Ramanathan and Carmichael, 2008). As we reduce greenhouse gas emissions and implement policies to eliminate air pollution, we are also reducing the concentration of aerosols in the air. Aerosols last in the atmosphere for about a week, so if we eliminate air pollution without reducing emissions of the greenhouse gases, the unmasking alone would lead to an estimated 0.7°C of warming within a matter of decades (Ramanathan and Feng, 2008). We must eliminate all aerosol emissions due to their health effects, but we must simultaneously mitigate emissions of CO2 , other greenhouse gases, and black carbon and co-pollutants to avoid an abrupt and very large jump in the near-term warming beyond 2°C (Brasseur and Roeckner, 2005).

2. Tipping Points**: It is likely that as we cross the 1.5°C to 2°C thresholds we will trigger so called “tipping points” for abrupt and nonlinear changes in the climate system with catastrophic consequences** for humanity and the environment (Lenton, 2008; Drijfhout et al., 2015). Once the tipping points are passed, the resulting impacts will range in timescales from: disruption of monsoon systems (transition in a year), loss of sea ice (approximately a decade for transition), dieback of major forests (nearly half a century for transition), reorganization of ocean circulation (approximately a century for transition), to loss of ice sheets and subsequent sea-level rise (transition over hundreds of years) (Lenton et al., 2008). Regardless of timescale, once underway many of these changes would be irreversible (Lontzek et al., 2015). There is also a likelihood of crossing over multiple tipping points simultaneously. Warming of close to 3°C would subject the system to a 46% probability of crossing multiple tipping points, while warming of close to 5°C would increase the risk to 87% (Cai et al., 2016). Recent modeling work shows a “cluster” of these tipping points could be triggered between 1.5°C and 2°C warming (Figure 2), including melting of land and sea ice and changes in highlatitude ocean circulation (deep convection) (Drijfhout et al., 2015). This is consistent with existing observations and understanding that the polar regions are particularly sensitive to global warming and have several potentially imminent tipping points. The Arctic is warming nearly twice as quickly as the global average, which makes the abrupt changes in the Arctic more likely at a lower level of global warming (IPCC, 2013). Similarly, the Himalayas are warming at roughly the same rate as the Arctic and are thus also more susceptible to incremental changes in temperature (UNEP-WMO, 2011). This gives further justifcation for limiting warming to no more than 1.5°C.

While all climate tipping points have the potential to rapidly destabilize climate, social, and economic systems, some are also **self-amplifying feedbacks that once set in motion increase warming in such a way that they perpetuate yet even more warming. Declining Arctic sea ice, thawing permafrost, and the poleward migration of cloud systems are all examples of self-amplifying feedback mechanisms, where initial warming feeds upon itself to cause still more warming acting as a force multiplier (Schuur et al., 2015).**

### Solvency

#### Harmonized approaches to CRISPR solve misapplication – answers any impact turn

Wachowicz 19 [(Jessica, a third-year student at the University of Washington School of Law whose primary area of study is emerging technologies and the legal issues associated therewith.) “The Patentability of Gene Editing Technologies such as CRISPR & the Harmonization of Laws Relating to Germline Editing, “ Intellectual Property Breif, 2019 https://digitalcommons.wcl.american.edu/ipbrief/vol10/iss1/2/] RR

At present, countries take different approaches in applying the ordre public doctrine to cases involving germline editing. In Japan, the patent office examines scientific guidelines pertaining to stem cell research in rendering its decisions.8 1 Others simply look to the values held by that particular country in determining whether the invention would benefit society.82

Looking at the values held by a particular community will lead to varying results. Some countries may value the welfare of individuals over the progression of science.83 Others argue that because these inventions can dramatically improve healthcare, and because healthcare is a human right, this public interest should override any bans on germline editing. 84

A similar dispute arose under TRIPS with respect to pharmaceuticals. As stated previously, some countries, India in particular, argued that patenting pharmaceuticals was immoral because it raised the cost of healthcare. In 2016, the World Health Organization published the "Guidelines for the examination of patent applications relating to pharmaceuticals."86 The purpose of this guideline was to assist legislators in crafting laws that would allow for the patentability of pharmaceuticals generally, while imposing limitations that would prevent healthcare from becoming unaffordable.

One plausible solution is for the World Health Organization to create a set of guidelines for determining the patentability of technologies such as CRISPR. The guideline can look to other international treaties that focus on the preservation of human rights and the improvement of healthcare.87 By encouraging countries to take these agreed upon policy objectives into consideration when examining these controversial patents, results among different patent offices may be slightly less varied. A guideline from the World Health Organization (WHO) or a similar organization may assist countries' legislatures in crafting laws that allow for progression in this field of science while protecting their communities from potential human rights violations, such as the destruction of viable embryos.

Attempts at harmonization have been made in the past. There are currently numerous international instruments that prohibit inventions involving genomes, such as the UNESCO Universal Declaration on Bioethics and Human Rights and the Oviedo Convention for the Protection of Human Rights and Dignity of the Human Being with regard to the Application of Biotechnology and Medicine: Convention on Human Rights and Biomedicine. The former states that public welfare should be prioritized over the progress of science, and the latter states that genetic modification techniques should only be allowed if "serious hereditary sexrelated disease[s] [are] to be avoided."89 These agreements make clear that public welfare is of primary importance, and that germline editing techniques should only be applied where serious risks can be avoided. The Oviedo Convention limited the scope of the exception to the avoidance of sex-related diseases, but perhaps with the introduction of CRISPR, countries may need to consider the circumstances under which genome and germline editing may be permissible.

CONCLUSION

In summary, relying on the ordre public doctrine to determine the patentability of CRISPR technology will lead to dramatically varying results around the world. The need for a more harmonized approach is present. Despite countries' general avoidance of genome and germline editing, technology has developed in such a way that these practices may be highly beneficial to public welfare. Countries should reconsider their stances on such practices in light of the potential benefits CRISPR technology can offer and should attempt to reach a general consensus on the proper uses of CRISPR. Given recent events, the WHO should promptly issue guidelines to assist legislatures in crafting laws that promote progress in this area while maintaining consistency with concepts of morality.

### Framing

**Moral uncertainty means preventing extinction should be our highest priority.**  
**Bostrom 12** [Nick Bostrom. Faculty of Philosophy & Oxford Martin School University of Oxford. “Existential Risk Prevention as Global Priority.” Global Policy (2012)]  
These reflections on **moral uncertainty suggest** an alternative, complementary way of looking at existential risk; they also suggest a new way of thinking about the ideal of sustainability. Let me elaborate.¶ **Our present understanding of axiology might** well **be confused. We may not** nowknow — at least not in concrete detail — what outcomes would count as a big win for humanity; we might not even yet **be able to imagine the best ends** of our journey. **If we are** indeedprofoundly **uncertain** about our ultimate aims,then we should recognize that **there is a great** option **value in preserving** — and ideally improving — **our ability to recognize value and** to **steer the future accordingly. Ensuring** that **there will be a future** version of **humanity** with great powers and a propensity to use them wisely **is** plausibly **the best way** available to us **to increase the probability that the future will contain** a lot of **value.** To do this, we must prevent any existential catastrophe.

**Reducing the risk of extinction is always priority number one.   
Bostrom 12** [Faculty of Philosophy and Oxford Martin School, University of Oxford.], Existential Risk Prevention as Global Priority.  Forthcoming book (Global Policy). MP. http://www.existenti...org/concept.pdfEven if we use the most conservative of these estimates, which entirely ignores the   possibility of space colonization and software minds, **we find that the expected loss of an existential   catastrophe is greater than the value of 10^16 human lives**.  **This implies that the expected value of   reducing existential risk by a mere one millionth of one percentage point is at least a hundred times the   value of a million human lives.**  The more technologically comprehensive estimate of 10  54 humanbrain-emulation subjective life-years (or 10  52  lives of ordinary length) makes the same point even   more starkly.  Even if we give this allegedly lower bound on the cumulative output potential of a   technologically mature civilization a mere 1% chance of being correct, we find that the expected   value of reducing existential risk by a mere one billionth of one billionth of one percentage point is worth   a hundred billion times as much as a billion human lives. **One might consequently argue that even the tiniest reduction of existential risk has an   expected value greater than**

**that of the definite provision of any ordinary good, such as the direct   benefit of saving 1 billion lives.**  And, further, that the absolute value of the indirect effect of saving 1  billion lives on the total cumulative amount of existential riskâ€”positive or negativeâ€”is almost   certainly larger than the positive value of the direct benefit of such an action.