## 1AC v1

### 1AC – Advantage

#### Scenario 1 is cancer

#### Synthetic biology solves cancer.

**Jain 12** [Kewal K. Jain, Consultant in biotechnology and pharmaceutical medicine. Research in cell/gene therapy, neuroprotection, and nanobiotechnology. Reviewer, research grant applications for government agencies in Canada, USA (US Army) and Europe (European Commission, the Netherlands, Austria, Finland, Estonia and UK). Chairman of the Scientific Advisory Board, Genometrica Ltd, Lugano, Switzerland. Member of Board of Managers of Progenitor Cell Therapy 2006-2010, until takeover of the company by NeoStem Inc. Member Editorial Board, Nanomedicine, published by Future Medicine. Member Editorial Board, Technology in Cancer Research and Treatment, Adenine Press. Member International Advisory Board, Medical Principles & Practice, Karger. Consultant in Neurology Senior Associate editor, MedLink Corporation, San Diego, California. 08-16-2012, accessed on 9-11-2021, PubMed Central (PMC), "Synthetic Biology and Personalized Medicine", <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5586729/>] Adam

Most of the current treatments of cancer do not discriminate between cancer and normal tissues. Besides individual variations, personalized therapy takes into consideration the fact that cancer varies both genetically and phenotypically among patients who may have identical type and stage of cancer. Personalized therapy aims to deliver therapy to the malignant tumors while sparing normal tissues. Synthetic biology provides many opportunities for design of personalized therapies for cancer.

Sequencing, Synthetic Biology and Personalized Therapy of Cancer

Discoveries made through application of human genome sequencing have already an impact on practice of oncology and have influenced the design of clinical trials for new cancer therapies. In the future, research into cancer will expand to generate full genome sequences of various cancers, yielding complete catalogues of somatic mutations in each one. These studies will reveal essentially the full repertoire of mutated cancer genes, enabling us to determine how many and what combinations of mutated cancer genes are necessary to generate an individual cancer. Sequencing is evolving from a research tool to applications for cancer diagnostics. Analyses of the cancer genome as well as the transcriptome and their applications into clinical trials in order to exploit the full clinical potential of information within the cancer genome are generating new predictors of drug responsiveness and prognosis, which will enable personalized management of cancer [[36](https://www.karger.com/Article/Fulltext/341794#ref36)].

Synthetic Bacteria for Personalized Eradication of Brain Cancer

Bacteria can be synthetically engineered to target, invade and destroy cancer cells selectively, or knock down a specific, endogenous cancer-related network of genes. An example of the potential application of this approach is brain cancer (glioblastoma multiforme), which is one of the most challenging cancers, and efforts to cure it have failed in over 100 years of history of modern neurosurgery. The challenge is due to complete eradication required for cure as even a few residual cells multiply rapidly with recurrence of the tumor that kills the patient. Response to conventional treatments such as surgical resection and chemotherapy varies according to the characteristics of individual tumors, but none are curative.

One of the innovations is the use of genetically modified bacteria to selectively destroy the tumor without invading the surrounding normal brain [[37](https://www.karger.com/Article/Fulltext/341794#ref37)]. Genetic modification of bacteria is complicated as it requires selection of aggressive invasive species and extensive modifications, i.e. excision of harmful genes and insertion of genes for selective destruction of the tumor. Synthetic bacteria may be easier to construct and designed according to the characteristics of an individual tumor and the required tasks with better prospects of cure.

#### Contagious Cancer is a major and legitimate threat AND causes extinction.

Johnson 16 George Johnson 2-23-2016 “Scientists Ponder the Prospect of Contagious Cancer” <https://www.nytimes.com/2016/02/23/science/scientists-ponder-the-prospect-of-contagious-cancer.html?mcubz=0> (columnist and science journalist for the New York Times, M.A. in Journalism and Public Affairs, American University)//Elmer

For all its peculiar horror, cancer comes with a saving grace. If nothing else can stop a tumor’s mad evolution, the cancer ultimately dies with its host. Everything the malignant cells have learned about outwitting the patient’s defenses — and those of the oncologists — is erased. The next case of cancer, in another victim, must start anew. Imagine if instead, cancer cells had the ability to press on to another body. A cancer like that would have the power to metastasize not just from organ to organ, but from person to person, **evolving deadly new skills** along the way. While there is no sign of an imminent threat, several recent papers suggest that the eventual emergence of a contagious human cancer is in the realm of medical possibility. This would **not be a disease**, like cervical cancer, that is set off by the spread of viruses, but rather one in which cancer cells actually travel from one person to another and thrive in their new location. So far this is known to have happened only under the most unusual circumstances. A 19-year-old laboratory worker who pricked herself with a syringe of colon cancer cells developed a tumor in her hand. A surgeon acquired a cancer from his patient after accidentally cutting himself during an operation. There are also cases of malignant cells being transferred from one person to another through an organ transplant or from a woman to her fetus. On each of these occasions, the malignancy went no further. The only known cancers that continue to move from body to body, evading the immune system, have been found in other animals. In laboratory experiments, for instance, cancer cells have been transferred by mosquitoes from one hamster to another. And so far, three kinds of contagious cancers have been discovered in the wild — in dogs, Tasmanian devils and, most recently, in soft shell clams. The oldest known example is a cancer that spreads between dogs during sexual intercourse — not as a side effect of a viral or bacterial infection, but rather through direct conveyance of cancer cells. The state of the research is described in a review, “The Cancer Which Survived,” published last year by Andrea Strakova and Elizabeth P. Murchison of the University of Cambridge. The condition, canine transmissible venereal tumor disease, is believed to have sprung into existence 11,000 years ago — as a single cell in a single dog — and has been circulating ever since. (Why did this happen in dogs and not, say, cats? Perhaps because of what the authors demurely call the dogs’ “long-lasting coital tie” — the half an hour or so that a male and female are locked in intercourse, tearing genital tissues and providing the cancer cells with a leisurely crossing.) Normally a cancer evolves in a single body over the course of years or decades, accumulating the mutations that drive it to power. But to have survived for millenniums, researchers have proposed, canine cancer cells may have developed mechanisms — like those in healthy cells — to repair and stabilize their own malignant genomes. Early on, cancer cells typically flourish by **disabling DNA repair** and ramping up the **mutational frenzy**. Somewhere along the way, the age-old canine cells may have reinvented the device to extend their own longevity. There is also speculation that this cancer may have learned to somehow modify canine sexual behavior in ways that promote the disease’s spread and survival. The second kind of contagious cancer **was discovered in** the mid-1990s in **Tasmanian devils**, which spread malignant cells as they try to tear off one another’s faces. Though it may be hard to sympathize, devil facial tumor disease threatens the creatures with extinction. With so few examples, transmissible cancer has been easy to dismiss as an aberration. But in December, scientists at the Universities of Tasmania and Cambridge reported in Proceedings of the National Academy of Sciences that Tasmanian devils are passing around another kind of cancer — genetically distinct from the first. It’s weird enough that one such cancer would arise in the species. What are the chances that there would be two? One theory is that the animals are unusually vulnerable. Driven so close to extinction — by climate change, perhaps, or human predators — the species is lacking in genetic diversity. The cells of another devil injected through a vicious wound may seem so familiar that they are ignored by the recipient’s immune system. If some of the cells carry the mutations for the facial cancer, they might be free to flourish and develop into a new tumor. But the scientists also proposed a more disturbing explanation: that the emergence of contagious cancer may not be so rare after all. “The possibility,” they wrote, “warrants further investigation of the risk that such diseases could arise in humans.” Cancer has probably existed ever since our first multicellular ancestors appeared on Earth hundreds of millions of years ago. The life spans of even the longest-lived animals may be just too brief for cancers to easily evolve the ability to leap to another body. Otherwise, contagious cancer would be everywhere.

#### Scenario 2 is biodiversity

#### We can still reverse the worst impacts of global warming.

Chrobak, 21 [Ula Chrobak, environmental contributor at PopularScience, 26 April 2021, PopularScience, “We can avoid the worst effects of climate change, but we’re still in for a fight,” <https://www.popsci.com/story/environment/reverse-climate-threshold/>, accessed 8-10-21]JMK

It’s easy to get disheartened about climate change. To keep global warming within the safe threshold of 1.5ºC adopted by the Paris Agreement, we need to have declines in carbon emissions on par with those of 2020, a year in which a global pandemic forced transportation and industry to slow down. As economies rev back up, it’s understandable to be anxious that things will return back to “normal,” a planet-wrecking status quo.

But even if the odds of global leaders shifting gears to focus on mitigating climate change are low, it’s not cause for **climate doomerism**. Every bit of warming we ward off helps. A new review in the journal Nature illustrates that even if we overshoot a global warming threshold, it won’t necessarily destabilize crucial Earth systems—including ice sheets, ocean currents, and tropical forests—right away. “If you change [the course of emissions] fast enough, you can avoid certain consequences that might be otherwise irreversible,” says Valerio Lucarini, a physicist at the University of Reading who was not involved in the study. “I think the paper does a good job in making this clear.”

Global warming targets like 1.5ºC are based on what researchers think is needed to avoid setting off powerful and irreversible changes to the biosphere that could devastate humans and ecosystems. But Paul Ritchie, a climate scientist at the University of Exeter who led the study, says that a common misconception is that once we cross a climate threshold, all is lost—that processes like ice melt will spin out of control until the Earth equilibrates at a new, hotter normal. “You often hear that we are very close to the threshold now [for ice sheet collapse]—some say we’ve already crossed it—and that means, apparently, that we’re committed to suffering a large [amount of] ice melt,” he says. “That’s not necessarily the case.”

Carefully sip a hot coffee and you won’t burn your tongue. Hold a big gulp in your mouth and everything will taste funny for the rest of the day. Similarly, ice sheets and ocean currents can take extra heat for a while. But if we keep temperatures over their threshold for too long, that’s when we’ll actually get irreversible climate impacts.

To illustrate this concept, Ritchie developed a mathematical model to test climate overshoot scenarios for various systems. In the recent paper, he tested this model on four key climate tipping points: ice cap melting, Amazon forest dieback, disrupted Indian summer monsoons, and the collapse of the Atlantic Meridional Overturning Circulation (AMOC), a major ocean circulation system that redistributes heat from equatorial waters.

Each of these processes has a unique thermal threshold, at which a tipping point could be set off. A tipping point is when a system moves from one stable state into a new one. It can be hard to go back once this happens. Imagine two valleys separated by a mountain. At a certain temperature, a system like the Amazon rainforest gets pushed to its limit, rolling into the metaphorical next valley over and becoming a new type of ecosystem. Once there, it will be nearly impossible to return the now-treeless landscape back to its former lush state.

But this new paper shows that a threshold can be tripped without a system immediately shifting into a new state. How much it can handle is based on its individual sensitivity to warmer temperatures, how fast we can cool the planet back down, and at what point global warming eventually stabilizes. The rate at which we cross a threshold temperature also matters—the slower we go, the more likely we are to avoid setting off a tipping point.

Some tipping points are slow to manifest, while others might occur on a much shorter timescale. Ritchie and his team found that we have multiple centuries during which to stabilize global temperatures at 1.5ºC before the ice caps melt and the AMOC collapses. But tropical forests and monsoons don’t have as much time. Especially if we overshoot a lot (such as by bringing on temperatures of about 4ºC or more above pre industrial times), Amazon rainforests might only have a few years before they start dying at large scale, and Indian summer monsoons just a few decades before they are disrupted. If we cross the Paris Agreement target, just how much the planet is permanently altered depends on how fast we can cool the atmosphere back down.

#### Synthetic biology solves warming and oil spills

**Rusten 19** [Marte Rusten, Principal Consultant Environmental Risk and Preparedness at the DNV 2019, accessed on 9-11-2021, DNV, "Restoring ecosystems through synthetic biology", <https://www.dnv.com/to2030/technology/restoring-ecosystems-through-synthetic-biology.html>] Adam

It is well known that many microbes can naturally decontaminate soil or water.  In a process called bioremediation, microbes use pollutants as energy to break down organic compounds and absorb unwanted inorganic substances from the environment. Synthetic biology is used to enhance these capabilities by creating gene-modified microorganisms that can be used to restore the balance of nature in the wake of pollution incidents5.  As an example, much research is underway to identify how bacterial enzymes with the ability to degrade PET-plastic (a significant pollutant in many environments6). These microorganisms can be used as part of the process at recycling sites or introduced into polluted environments to degrade unwanted plastics.

Synthetic biology is also used to capture CO2 from the atmosphere and convert it into usable products by genetically modifying CO2-fixing organisms. One interesting example is how bacteria fed with CO2 can produce proteins to replace fish in fishmeal7. As a result, synthetic biology could help reduce CO2 in the atmosphere while also reducing the need for fish.

Another example is the creation of synthetic jellyfish that can break down and absorb toxic chemicals when they are released into marine environments after toxic spills8. As the jellyfish are designed to avoid replication and can be programmed to “die” after a certain time, they can be released into the environment in immense numbers, perform their job and disintegrate and disappear from the ecosystem. The technology to design such synthetic organisms (biomimetic multicellular structures) is still under development, but it has significant potential in the future clean-up of polluted marine ecosystems. Preserving biodiversity

Synthetic biology can also be used to preserve biodiversity by strengthening organisms’ resilience to external threats. Genetic modifications to living organisms and the use of ‘gene drives’ and can help us preserve biodiversity caused by threats to the ecosystems.

#### Repealing of safety protocols has made us more vulnerable to oil spills than ever

**D'Angelo 20** [Chris D'Angelo, an associate editor at HuffPost Hawaii, He covers public lands, climate change, biodiversity, and environmental policy, He is a member of the Society of Environmental Journalists and his reporting has won awards from the Society of Professional Journalists Hawaii Chapter and the Hawaii Publishers Association, 4-20-20, accessed on 3-17-2021. “10 years after Deepwater Horizon, the U.S. is even more at risk of a major oil spill”, Grist, <https://grist.org/energy/10-years-after-deepwater-horizon-the-u-s-is-even-more-at-risk-of-a-major-oil-spill/>] Adam

But a decade after Deepwater, experts and environmental advocates warn that the U.S. remains woefully unprepared for a major spill — and is perhaps even more at risk of one due to the Trump administration’s relentless push to expand offshore drilling and gut environmental regulations. “The question of whether we’re any better off — my concern is we’re actually headed towards the exact same type of circumstances that were in place” at the time of the Deepwater disaster, Elizabeth Johnson Klein, the Interior Department’s associate deputy secretary under Obama, told HuffPost. “I don’t feel good about it.” The Trump administration’s “energy dominance” agenda has put pressure on industry to develop in new, riskier, and more expensive areas, Klein said. When companies are forced to cut costs, safety is typically one of the first things to take a back seat. Then there’s the industry-tied political leaders at Trump’s Interior Department, who Klein says “have not demonstrated that they’ve learned lessons from Deepwater Horizon.” Interior Secretary David Bernhardt is a former oil and gas lobbyist whose clients included Halliburton, the oil services giant that in 2014 agreed to a $1.1 billion settlement for its role in the 2010 blowout. Scott Angelle, the director of the Bureau of Safety and Environmental Enforcement, is a former board member of oil and gas pipeline company Sunoco Logistics Partners LP who, during his brief stint as lieutenant governor of Louisiana, led the state’s push to lift the moratorium on offshore drilling in the Gulf that the Obama administration put in place after Deepwater Horizon. With little regard for climate change and other environmental impacts, the Trump administration has sought to transform the U.S. into the world’s leading fossil fuel behemoth. In January 2018, it rolled out a controversial plan to make nearly all U.S. waters — roughly 90 percent of the U.S. Outer Continental Shelf — available for oil and gas leasing, including large swaths of the Arctic, Atlantic, and Pacific Oceans. In its proposal, Trump’s Interior Department cited Obama-era safety regulations put in place after Deepwater Horizon, noting that while offshore oil and gas production “will never be totally risk-free” the agency “has made, and is continuing to make, substantial reforms to improve the safety.” Those changes, it said, included rules to reduce the risk of a rig losing control of a well, as happened in the Deepwater disaster. The administration then turned around and gutted the very safeguards it highlighted to make its case for expanded drilling, arguing that the regulations were burdensome on offshore producers. It weakened the Production Safety Systems Rule, loosening notification and certification rules for fossil fuel companies and scrapping a requirement that offshore equipment be designed to withstand the most extreme weather and pressure conditions. And it overhauled the Well Control Rule, a monitoring regulation that took effect in 2016 and required additional inspection and maintenance of blowout preventers, devices designed to automatically seal a well and stop an uncontrolled release of oil and gas. The Trump rollback eased inspection and oversight requirements. “Today’s final rule puts safety first, both public and environmental safety, in a common sense way,” Bernhardt said in a statement at the time. With fewer safeguards in place, the administration has plowed ahead with offshore leasing. Last month, as the deadly coronavirus pandemic gripped the nation, Interior offered at auction 78 million acres in the Gulf of Mexico to oil and gas producers. The lease sale brought in approximately $93 million for just shy of 400,000 acres, the smallest total for an offshore auction since 2016. “As I see it, the essential lesson from Deepwater Horizon is that industry and government should be putting their greatest energies into preventing operational accidents, blowouts, and releases,” Donald Boesch, a professor of marine science at the University of Maryland who served on the bipartisan commission that investigated the causes of the Deepwater Horizon, wrote in a recent piece published in The Conversation. “Yet the Trump administration emphasizes increasing production and reducing regulations. This undermines safety improvements made over the past 10 years.” The seven-member oil spill commission concluded in a 2011 report that a “culture of complacency” by both industry and government led to the Deepwater disaster. And while industry often says that offshore drilling has never been safer, others see things quite differently. “Never safer than what?” Mark Davis, director of the Institute on Water Resources Law and Policy at Tulane University, said during a call with reporters last week. The underlying issue prior to Deepwater Horizon and still today is that the federal government has a “financial stake in the success” of offshore fossil fuel development, he said. Extracting oil is driven by policy rather than data. “It was policy to believe that bad things wouldn’t happen, and it was policy that you don’t waste time planning for things that aren’t going to happen,” Davis said. “Until we get our policies and legal architecture in line with the risks we are running, we are going to be very vulnerable,” he added. Last week, ahead of the 10-year anniversary of Deepwater Horizon, ocean advocacy group Oceana published a report that documented the many economic and environmental impacts of the spill and concluded that “the poor safety culture and lack of oversight that led to the BP disaster persist.” “If anything, another disaster is more likely, because the industry is drilling deeper and farther offshore, which increases the likelihood of a spill and makes responding to a spill more difficult,” the report stated. “Indeed, Deepwater Horizon is not the worst-case scenario,” Ian MacDonald, an oceanography professor at Florida State University, said on a call with reporters last week. The next one could be far more catastrophic — perhaps on par with the ongoing Taylor oil spill, which began in September 2004, after Hurricane Ivan ripped through the Gulf of Mexico and triggered submarine mudslides that toppled a Taylor Energy platform 11 miles off the coast of Louisiana. At least 25 wells were damaged, and oil has been leaking from the site for the last 15 years. A federal government study published in June 2019 and coauthored by McDonald estimated that as much as 4,500 gallons of oil is leaking from the site each day ― a figure orders of magnitude higher than Taylor’s estimates. McDonald warned this could be the future of deep ocean oil spills. Subsea landslides are not unusual in the Gulf of Mexico, and are often the result of earthquakes. More than 50 percent of the oil produced in the Gulf is from platforms at depths greater than 1,000 meters, McDonald said.

#### Oil spills cause extinction

Adams 10 [Mike Adams, Mike Adams is a best-selling author and a globally recognized scientific researcher in clean foods. He serves as the founding editor of NaturalNews.com and the lab science director of an internationally accredited (ISO 17025) analytical laboratory known as CWC Labs. There, he was awarded a Certificate of Excellence for achieving extremely high accuracy in the analysis of toxic elements in unknown water samples using ICP-MS instrumentation. Adams is also highly proficient in running liquid chromatography, ion chromatography and mass spectrometry time-of-flight analytical instrumentation. Adams is the founder and publisher of the open source science journal Natural Science Journal, the author of numerous peer-reviewed science papers published by the journal, and the author of the world's first book that published ICP-MS heavy metals analysis results for foods, dietary supplements, pet food, spices and fast food. 5-8-2010, accessed on 3-17-2021, Natural News, "Is Gulf oil rig disaster far worse than we're being told?", <https://www.naturalnews.com/028749_Gulf_of_Mexico_oil_spill.html>] Adam

The possibility of an extinction event? It's hard to say exactly what's going on in the Gulf right now, especially because there are so many conflicting reports and unanswered questions. But one thing's for sure: if the situation is actually much worse than we're being led to believe, there could be worldwide catastrophic consequences. If it's true that millions upon millions of gallons of crude oil are flooding the Gulf with no end in sight, the massive oil slicks being created could make their way into the Gulf Stream currents, which would carry them not only up the East Coast but around the world where they could absolutely destroy the global fishing industries. Already these slicks are making their way into Gulf wetlands and beaches where they are destroying birds, fish, and even oyster beds. This is disastrous for both the seafood industry and the people whose livelihoods depend on it. It's also devastating to the local wildlife which could begin to die off from petroleum toxicity. Various ecosystems around the world could be heavily impacted by this spill in ways that we don't even yet realize. There's no telling where this continuous stream of oil will end up and what damage it might cause. Theoretically, we could be looking at modern man's final act of destruction on planet Earth, because this one oil rig blowout could set in motion a global extinction wave that begins with the oceans and then whiplashes back onto human beings themselves. We cannot live without life in the oceans. Man is arrogant to drill so deeply into the belly of Mother Earth, and through this arrogance, we may have just set in motion events that will ultimately destroy us. In the future, we may in fact talk about life on Earth as "pre-spill" versus "post-spill." Because a post-spill world may be drowned in oil, devoid of much ocean life, and suffering a global extinction event that will crash the human population by 90 percent or more.

#### Climate change destroys the world.

Specktor 19 [Brandon writes about the science of everyday life for Live Science, and previously for Reader's Digest magazine, where he served as an editor for five years] 6-4-2019, "Human Civilization Will Crumble by 2050 If We Don't Stop Climate Change Now, New Paper Claims," livescience, <https://www.livescience.com/65633-climate-change-dooms-humans-by-2050.html> Justin

The current climate crisis, they say, is larger and more complex than any humans have ever dealt with before. General climate models — like the one that the [United Nations' Panel on Climate Change](https://www.ipcc.ch/sr15/) (IPCC) used in 2018 to predict that a global temperature increase of 3.6 degrees Fahrenheit (2 degrees Celsius) could put hundreds of millions of people at risk — fail to account for the **sheer complexity of Earth's many interlinked geological processes**; as such, they fail to adequately predict the scale of the potential consequences. The truth, the authors wrote, is probably far worse than any models can fathom. How the world ends What might an accurate worst-case picture of the planet's climate-addled future actually look like, then? The authors provide one particularly grim scenario that begins with world governments "politely ignoring" the advice of scientists and the will of the public to decarbonize the economy (finding alternative energy sources), resulting in a global temperature increase 5.4 F (3 C) by the year 2050. At this point, the world's ice sheets vanish; brutal droughts kill many of the trees in the [Amazon rainforest](https://www.livescience.com/57266-amazon-river.html) (removing one of the world's largest carbon offsets); and the planet plunges into a feedback loop of ever-hotter, ever-deadlier conditions. "Thirty-five percent of the global land area, and **55 percent of the global population, are subject to more than 20 days a year of** [**lethal heat conditions**](https://www.livescience.com/55129-how-heat-waves-kill-so-quickly.html), beyond the threshold of human survivability," the authors hypothesized. Meanwhile, droughts, floods and wildfires regularly ravage the land. Nearly **one-third of the world's land surface turns to desert**. Entire **ecosystems collapse**, beginning with the **planet's coral reefs**, the **rainforest and the Arctic ice sheets.** The world's tropics are hit hardest by these new climate extremes, destroying the region's agriculture and turning more than 1 billion people into refugees. This mass movement of refugees — coupled with [shrinking coastlines](https://www.livescience.com/51990-sea-level-rise-unknowns.html) and severe drops in food and water availability — begin to **stress the fabric of the world's largest nations**, including the United States. Armed conflicts over resources, perhaps culminating in **nuclear war, are likely**. The result, according to the new paper, is "outright chaos" and perhaps "the end of human global civilization as we know it."

#### Scenario 3 is food shortages

#### Synthetic biotech is key to agricultural sustainability

Wurtzel et al 19 [Eleanor T. Wurtzel, Department of Biological Sciences, Lehman College, City University of New York, Graduate School and University Center-CUNY; Claudia E. Vickers, CSIRO Synthetic Biology Future Science Platform, Australian Institute for Bioengineering & Nanotechnology, University of Queensland; Andrew D. Hanson, Horticultural Sciences Department, University of Florida; A. Harvey Millar, ARC Centre of Excellence in Plant Energy Biology, School of Molecular Sciences, University of Western Australia; Mark Cooper, Queensland Alliance for Agriculture & Food Innovation, University of Queensland; Kai P. Voss-Fels, Queensland Alliance for Agriculture & Food Innovation, University of Queensland; Pablo I. Nikel, Novo Nordisk Foundation Center for Biosustainability, Technical University of Denmark; Tobias J. Erb, Max-Planck-Institute for Terrestrial Microbiology, Department of Biochemistry & Synthetic Metabolism, LOEWE Center for Synthetic Microbiology, December 2019, Nature Plants, “Revolutionizing agriculture with synthetic biology,” volume 5, no. 12, pg. 1-2, DOI: 10.1038/s41477-019-0539-0, accessed 8-12-2021] JMK recut Adam

Agricultural sustainability by design

There is every reasonable expectation that SynBio can drive unprecedented leaps in biomass and harvested yields, and at the same time improve the health of the agroecosphere2,12. We have first-generation examples of progress in these areas and of next-generation approaches that are in the pipeline now or soon will be. Together, these approaches add up to ‘sustainability by design’, as illustrated below.

Increasing net carbon fixation by crops can increase yields and, if some of the extra fixed carbon is partitioned to roots, it can also increase net long-term storage of carbon in the soil, thereby both improving soil quality and stripping CO2 from the air. Very encouragingly, installing synthetic photorespiratory pathways in tobacco boosted biomass production in the field by >40%13. For the future, researchers are developing even more daring ways to reconfigure photorespiration (for example, to make it carbon-conserving), to engineer novel carboxylases and synthetic CO2 fixation pathways that have no natural counterparts (Fig. 1), and to give crops CO2- concentrating mechanisms to enhance the efficiency of RubisCO8,14. Complementary to increasing carbon gain, approaches to cut respiratory carbon loss by increasing the energy efficiency of metabolic and transport processes are likewise gaining traction15.

As with metabolic pathways that are not optimally tailored for today’s agricultural conditions, so with plant architecture and development. Thus, coupling synthetic biosensors for endogenous signalling molecules or metabolites to specific regulatory elements can reprogram the formation of cells, tissues and organs16 to create ‘smart plants’ that adjust to the environment in new ways. Similarly, engineering an abscisic acid receptor to be activated by a synthetic molecule (that can be sprayed on a crop) can enable intervention to reduce water use in response to inputs (weather forecasts) that plants themselves cannot acquire17. Yet another fast-developing biosensor application is in the design of ‘sentinel plants’ that, through engineered biosensors hooked to suitable output circuitry, can monitor environmental cues ranging from nutrient levels to pollutants2,16

#### Food insecurity goes Nuclear

FDI 12 [Future Directions International, a Research institute providing strategic analysis of Australia’s global interests; citing Lindsay Falvery, PhD in Agricultural Science and former  Professor at the University of Melbourne’s Institute of Land and Environment, “Food and Water Insecurity: International Conflict Triggers and Potential Conflict Points,” [http://www.futuredirections.org.au/workshop-papers/537-international-conflict-triggers-and-potential-conflict-points-resulting-from-food-and-water-insecurity.html] //Elmer](http://www.futuredirections.org.au/workshop-papers/537-international-conflict-triggers-and-potential-conflict-points-resulting-from-food-and-water-insecurity.html%5d%20//Elmer)

There is a growing appreciation that the conflicts in the next century will most likely be fought over a lack of resources. Yet, in a sense, this is not new. Researchers point to the French and Russian revolutions as conflicts induced by a lack of food. More recently, Germany’s World War Two efforts are said to have been inspired, at least in part, by its perceived need to gain access to more food. Yet the general sense among those that attended FDI’s recent workshops, was that the scale of the problem in the future could be significantly greater as a result of population pressures, changing weather, urbanisation, migration, loss of arable land and other farm inputs, and increased affluence in the developing world. In his book, Small Farmers Secure Food, Lindsay Falvey, a participant in FDI’s March 2012 workshop on the issue of food and conflict, clearly expresses the problem and why countries across the globe are starting to take note. . He writes (p.36), “…if people are hungry, especially in cities, the state is not stable – riots, violence, breakdown of law and order and migration result.” “Hunger feeds anarchy.” This view is also shared by Julian Cribb, who in his book, The Coming Famine, writes that if “large regions of the world run short of food, land or water in the decades that lie ahead, then wholesale, bloody wars are liable to follow.” He continues: “An increasingly credible scenario for World War 3 is not so much a confrontation of super powers and their allies, as a festering, self-perpetuating chain of resource conflicts.” He also says: “The wars of the 21st Century are less likely to be global conflicts with sharply defined sides and huge armies, than a scrappy mass of failed states, rebellions, civil strife, insurgencies, terrorism and genocides, sparked by bloody competition over dwindling resources.” As another workshop participant put it, people do not go to war to kill; they go to war over resources, either to protect or to gain the resources for themselves. Another observed that hunger results in passivity not conflict. Conflict is over resources, not because people are going hungry. A study by the International Peace Research Institute indicates that where food security is an issue, it is more likely to result in some form of conflict. Darfur, Rwanda, Eritrea and the Balkansexperienced such wars. Governments, especially in developed countries, are increasingly aware of this phenomenon. The UK Ministry of Defence, the CIA, the US Center for Strategic and International Studies and the Oslo Peace Research Institute, all identify famine as a potential trigger for conflicts and possibly even nuclear war.

#### Scenario 4 is REMs

#### Synthetic biology allows for safe and efficient rare earth extraction.

**Katsnelson 20** [Alla Katsnelson reporter at C&N. 11-10-2020, accessed on 9-12-2021, Chemical and Engineering News, "Microbes can mine rare-earth elements in space", <https://cen.acs.org/biological-chemistry/synthetic-biology/Microbes-mine-rare-earth-elements/98/web/2020/11>] Adam

[SYNTHETIC BIOLOGY](https://cen.acs.org/topics/biological-chemistry.html#syntheticBiology) Microbes can mine rare-earth elements in space Rock-munching bacteria could one day extract the elements for building rovers and electronic equipment on Mars or the moon

Rock-munching microbes have a [weighty job in the mining industry](https://cen.acs.org/articles/90/i42/Mining-Microbes.html), extracting metals such as copper and gold from the earth. They could also extract rare-earth elements such as lanthanides, scandium, and yttrium—pricey minerals used in electronics and some metal alloys.

Such microbes could also help mining in space, according to a new study (Sci. Adv. 2020, DOI: [10.1038/s41467-020-19276-w](http://dx.doi.org/10.1038/s41467-020-19276-w)). Experiments conducted on the International Space Station (ISS) showed that the bacterium Sphingomonas desiccabilis was as efficient at extracting 14 different rare-earth elements from basalt under microgravity conditions similar to those on the moon and on Mars, as it is under Earth-like gravity.

That means a human settlement on the moon or on Mars could potentially extract rare-earth elements from the local surroundings to use in building rovers, electronic equipment, and other technology, says Charles Cockell, an astrobiologist at the University of Edinburgh, who led the study. “Wherever we go, we are going to have to mine planetary or asteroid materials to sustain a long-term presence in space,” he says. “Here is a demonstration of one particular approach.”

On the ISS, astronauts added the bacterium and basalt in miniature reactors under microgravity conditions and in specially designed incubators that contain centrifuges capable of simulating gravity on Mars and Earth. The team picked basalt because it has a high concentration of rare-earth metals and is similar to rock found on the moon and Mars. Fluids don’t mix as well in microgravity as they do on Earth, so Cockell and his colleagues speculated that the microbes might not munch the basalt as effectively. But after 3 weeks, the bugs turned out to perform similarly well under all three gravity conditions. “It was really the first mining experiment in space,” Cockell says.

#### New investments coming and companies are launching – economic incentives make space mining alluring

**Tosar 20** [(Borja Tosar, reporter) “Asteroid Mining: A New Space Race,” OpenMind BBVA, May 18, 2020, <https://www.bbvaopenmind.com/en/science/physics/asteroid-mining-a-new-space-race/>] TDI

This is not science fiction. There are now space mining companies, such as [Planetary Resources,](https://www.consensys.space/pr) which has already launched several mini-satellites to test several of its patents. Other companies like [Asteroid Mining Corporation](https://asteroidminingcorporation.co.uk/) or [Trans Astronautica Corporation,](https://www.transastracorp.com/) although still far from their goal, are already attracting millions of dollars of private investment interested in being on the front line of a possible future space business.

Is asteroid mining possible? This new space race already began back when the Hayabusa missions successfully returned a few grams of an asteroid’s regolith, so the technology to harvest asteroid material exists, we just have to change the scale. It is no longer a technological problem.

Is it economically viable? We are increasingly dependent on rare elements (such as those in the palladium group), which are expensive to exploit on Earth and come with a high environmental cost, so the sum of these two factors could make it profitable to travel to the asteroids to extract these raw materials. Astrophysicist Neil deGrasse argues that [the planet’s first trillionaire will undoubtedly be a space miner.](https://www.cnbc.com/2015/05/01/build-the-economy-here-on-earth-by-exploring-space-tyson.html)

#### Asteroid mining spikes the risk of satellite-dust collisions

Scoles 15 [(Sarah Scoles, freelance science writer, contributor at Wired and Popular Science, author of the books Making Contact and They Are Already Here) “Dust from asteroid mining spells danger for satellites,” New Scientist, May 27, 2015, <https://www.newscientist.com/article/mg22630235-100-dust-from-asteroid-mining-spells-danger-for-satellites/>] TDI

* Study this is citing – Javier Roa, Space Dynamic Group, Applied Physics Department, Technical University of Madrid. Casey J Handmer, Theoretical Astrophysics, California Institute of Technology. Both PhD Candidates. “Quantifying hazards: asteroid disruption in lunar distant retrograde orbits,” arXiv, Cornell University, May 14, 2015, <https://arxiv.org/pdf/1505.03800.pdf>

NASA chose the second option for its [Asteroid Redirect Mission](http://www.nasa.gov/content/what-is-nasa-s-asteroid-redirect-mission/), which aims to [pluck a boulder from an asteroid’s surface](https://www.newscientist.com/article/dn27243-rock-grab-from-asteroid-will-aid-human-mission-to-mars) and relocate it to a stable orbit around the moon. But an asteroid’s gravity is so weak that it’s not hard for surface particles to escape into space. Now a new model warns that debris shed by such transplanted rocks could intrude where many defence and communication satellites live – in geosynchronous orbit.

According to [Casey Handmer](http://www.caseyhandmer.com/) of the California Institute of Technology in Pasadena and Javier Roa of the Technical University of Madrid in Spain, 5 per cent of the escaped debris will end up in regions traversed by satellites. Over 10 years, it would cross geosynchronous orbit 63 times on average. A satellite in the wrong spot at the wrong time will suffer a damaging high-speed collision with that dust.

The study also looks at the “catastrophic disruption” of an asteroid 5 metres across or bigger. Its total break-up into a pile of rubble would increase the risk to satellites by more than 30 per cent ([arxiv.org/abs/1505.03800](http://arxiv.org/abs/1505.03800)).

#### Space dust wrecks satellites and debris exponentially spirals

Intagliata 17 [(Christopher Intagliata, MA Journalism from NYU, Editor for NPRs All Things Considered, Reporter/Host for Scientific American’s 60 Second Science) “The Sneaky Danger of Space Dust,” Scientific American, May 11, 2017, <https://www.scientificamerican.com/podcast/episode/the-sneaky-danger-of-space-dust/>] TDI

When tiny particles of space debris slam into satellites, the collision could cause the emission of hardware-frying radiation, Christopher Intagliata reports.

Aside from all the satellites, and the space station orbiting the Earth, there's a lot of trash circling the planet, too. Twenty-one thousand [baseball-sized chunks](https://www.scientificamerican.com/article/orbital-debris-space-fence/) of debris, [according to NASA](https://www.orbitaldebris.jsc.nasa.gov/faq.html). But that number's dwarfed by the number of small particles. There's hundreds of millions of those.

"And those smaller particles tend to be going fast. Think of picking up a grain of sand at the beach, and that would be on the large side. But they're going 60 kilometers per second."

Sigrid Close, an applied physicist and astronautical engineer at Stanford University. Close says that whereas mechanical damage—like punctures—is the worry with the bigger chunks, the dust-sized stuff might leave more insidious, invisible marks on satellites—by causing electrical damage.

"We also think this phenomenon can be attributed to some of the failures and anomalies we see on orbit, that right now are basically tagged as 'unknown cause.'"

Close and her colleague Alex Fletcher modeled this phenomenon mathematically, based on plasma physics behavior. And here's what they think happens. First, the dust slams into the spacecraft. Incredibly fast. It vaporizes and ionizes a bit of the ship—and itself. Which generates a cloud of ions and electrons, traveling at different speeds. And then: "It's like a spring action, the electrons are pulled back to the ions, ions are being pushed ahead a little bit. And then the electrons overshoot the ions, so they oscillate, and then they go back out again.”

That movement of electrons creates a pulse of electromagnetic radiation, which Close says could be the culprit for some of that electrical damage to satellites. The study is in the journal Physics of Plasmas. [Alex C. Fletcher and Sigrid Close, [Particle-in-cell simulations of an RF emission mechanism associated with hypervelocity impact plasmas](http://aip.scitation.org/doi/full/10.1063/1.4980833)]

#### Earth observation satellites key to warming adaptation

Alonso 18 [(Elisa Jiménez Alonso, communications consultant with Acclimatise, climate resilience organization) “Earth Observation of Increasing Importance for Climate Change Adaptation,” Acclimatise, May 2, 2018, <https://www.acclimatise.uk.com/2018/05/02/earth-observation-of-increasing-importance-for-climate-change-adaptation/>] TDI

Earth observation (EO) satellites are playing an increasingly important role in assessing climate change. By providing a constant and consistent stream of data about the state of the climate, EO is not just improving scientific outcomes but can also inform climate policy.

Managing climate-related risks effectively requires accurate, robust, sustained, and wide-ranging climate information. Reliable observational climate data can help scientists test the accuracy of their models and improve the science of attributing certain events to climate change. Information based on projections from models and historic data can help decision makers plan and implement adaptation actions.

Providing information in data-sparse regions

Ground-based weather and climate monitoring systems only cover about 30% of the Earth’s surface. In many parts of the world such data is incomplete and patchy due to poorly maintained weather stations and a general lack of such facilities.

EO satellites and rapidly improving satellite technology, especially data from open access programmes, offer a valuable source information for such data-sparse regions. This is especially important since countries and regions with a lack of climate data are often particularly vulnerable to climate change impacts.

International efforts for systematic observation

The importance of satellite-based observations is also recognised by the international community. Following the recommendations of the World Meteorological Organization’s (WMO) Global Climate Observing System (GCOS) programme, the UNFCCC strongly encourages countries that support space agencies with EO programmes to get involved in GCOS and support the programme’s implementation. The Paris Agreement highlights the need for and importance of effective and progressive responses to the threat of climate change based on the best available scientific knowledge. This implies that climate knowledge needs to be strengthened, which includes continuously improving systematic observations of the Earth’s climate.

To meet the need of such systematic climate observations, GCOS developed the concept of the Essential Climate Variable, or ECV. According to WMO, an ECV “is a physical, chemical or biological variable or a group of linked variables that critically contributes to the characterization of Earth’ s climate.” In 2010, 50 ECVs which would help the work of the UNFCCC and IPCC were defined by GCOS. The ECVs, which can be seen below, were identified due to their relevance for characterising the climate system and its changes, the technical feasibility of observing or deriving them on a global scale, and their cost effectiveness.

The 50 Essential Climate Variables as defined by GCOS.

One effort supporting the systemic observation of the climate is the European Space Agency’s (ESA) Climate Change Initiative (CCI). The programme taps into its own and its member countries’ EO archives that have been established in the last three decades in order to provide a timely and adequate contribution to the ECV databases required by the UNFCCC.

Robust evidence supporting climate risk management

Earth observation satellites can observe the entire Earth on a daily basis (polar orbiting satellites) or continuously monitor the disk of Earth below them (geostationary satellites) maintaining a constant watch of the entire globe. Sensors can target any point on Earth even the most remote and inhospitable areas which helps monitor deforestation in vast tropical forests and the melting of the ice caps.

Without insights offered by EO satellites there would not be enough evidence for decision makers to base their climate policies on, increasing the risk of maladaptation. Robust EO data is an invaluable resource for collecting climate information that can inform climate risk management and make it more effective.

#### Early warning satellites going dark signals attacks – causes miscalc and goes nuclear

Orwig 16 [(Jessica, MS in science and tech journalism from Texas A&M, BS in astronomy and physics from Ohio State) “Russia says a growing problem in space could be enough to spark a war,” Insider,’ January 26, 2016, <https://www.businessinsider.com/russia-says-space-junk-could-spark-war-2016-1>] TDI

NASA has already warned that the large amount of space junk around our planet is growing beyond our control, but now a team of Russian scientists has cited another potentially unforeseen consequence of that debris: War.

Scientists estimate that anywhere from 500,000 to 600,000 pieces of human-made space debris between 0.4 and 4 inches in size are currently orbiting the Earth and traveling at speeds over 17,000 miles per hour.

If one of those pieces smashed into a military satellite it "may provoke political or even armed conflict between space-faring nations," Vitaly Adushkin, a researcher for the Institute of Geosphere Dynamics at the Russian Academy of Sciences, reported in a paper set to be published in the peer-reviewed journal Acta Astronautica, which is sponsored by the International Academy of Astronautics.

Say, for example, that a satellite was destroyed or significantly damaged in orbit — something that a 4-inch hunk of space junk could easily do traveling at speeds of 17,500 miles per hour, Adushkin reported. (Even smaller pieces no bigger than size of a pea could cause enough damage to the satellite that it would no longer operate correctly, he notes.)

It would be difficult for anyone to determine whether the event was accidental or deliberate.

This lack of immediate proof could lead to false accusations, heated arguments and, eventually, war, according to Adushkin and his colleagues.

A politically dangerous dilemma

In the report, the Adushkin said that there have already been repeated "sudden failures" of military spacecraft in the last two decades that cannot be explained.

"So, there are two possible explanations," he wrote. The first is "unregistered collisions with space objects." The second is "machinations" [deliberate action] of the space adversary.

"This is a politically dangerous dilemma," he added.

But these mysterious failures in the past aren't what concerns Adushkin most.

It's a future threat of what experts call the cascade effect that has Adushkin and other scientists around the world extremely concerned.

The Kessler Syndrome

In 1978, American astrophysicist Donald Kessler predicted that the amount of space debris around Earth would begin to grow exponentially after the turn of the millennium.

Kessler 's predictions rely on the fact that over time, space junk accumulates. We leave most of our defunct satellites in space, and when meteors and other man-made space debris slam into them, you get a cascade of debris.

The cascade effect — also known as the Kessler Syndrome — refers to a critical point wherein the density of space junk grows so large that a single collision could set off a domino effect of increasingly more collisions.

For Kessler, this is a problem because it would "create small debris faster than it can be removed," Kessler said last year. And this cloud of junk could eventually make missions to space too dangerous.

For Adushkin, this would exacerbate the issue of identifying what, or who, could be behind broken satellites.

The future

So far, the US and Russian Space Surveillance Systems have catalogued 170,000 pieces of large space debris (between 4 and 8 inches wide) and are currently tracking them to prevent anymore dilemmas like the ones Adushkin and his colleagues cite in their paper.

But it's not just the large objects that concern Adushkin, who reported that even small objects (less than 1/3 of an inch) could damage satellites to the point they can't function properly.

Using mathematical models, Adushkin and his colleagues calculated what the situtation will be like in 200 years if we continue to leave satellites in space and make no effort to clean up the mess. They estimate we'll have:

1.5 times more fragments greater than 8 inches across

3.2 times more fragments between 4 and 8 inches across

13-20 times more smaller-sized fragments less than 4 inches across

"The number of small-size, non-catalogued objects will grow exponentially in mutual collisions," the researchers reported.

#### Scenario 5 is Space Col

#### Genetically modified organisms are necessary for space colonization---key to food production, life support, medicine, and terraforming, and its key to ensure human survival from earth-only crises.

Warmflash, 17 [David Warmflash, Director of Medical Research at MGENUITY CORPORATION, Post-doctoral fellow, Department of Radiation Oncology, University of Pennsylvania, former Co-Investigator – NASA EVA/EMU Related Medical Issues team, Universities Space Research Associates, former NASA Astrobiology Institute NRC post doctoral fellow, 8 September 2017, GeneticLiteracyProject, “Quest to colonize space demands boost from biotechnology, synthetic biology,” <https://geneticliteracyproject.org/2017/09/08/quest-colonize-space-demands-boost-biotechnology-synthetic-biology/>, accessed 8-10-2021]JMK

As vital as synthetic biology will be to the early piloted missions to Mars and voyages of exploration, it will become indispensable to establish a long-term human presence off-Earth, namely colonization. That’s because we’ve evolved over billions of years to thrive specifically in the environments provides by our home planet.

Our physiology is well-suited to Earth’s gravity and its oxygen-rich atmosphere. We also depend on Earth’s global magnetic field to shield us from intense space radiation in the form of charged particles. In comparison, Mars has only patches of localized magnetism, thought to be remnants of a global magnetic field in the distant past. Currently, the Red Planet has no global magnetic field that could trap particle radiation from interplanetary space. Also, the Martian atmosphere is so thin that any shielding against space radiation of any kind is minor compared with the protection that Earth’s atmosphere affords. At the Martian surface, atmospheric pressure never gets above 7 millibars. That’s like Earth at an altitude of about 27,000 m (89,000 ft), which is almost the edge of space. And while the moon’s proximity to Earth could make it a better location than Mars for the first off-world colony, the lunar radiation environment is similar to that of Mars. That’s because the moon has practically no atmosphere at all, plus it too lacks a global magnetic field. On the moon, or on Mars, early colonists must live underground.

Living off the land: Creating Earth-like environments away from Earth

Living anywhere in our Solar System beyond Earth will require the same level of protection that an astronaut needs while walking in space. A human-friendly environment must be provided to sustain life, and for long-term human presence that environment must be sustainable. In contrast to short flights into low-Earth orbit, or brief visits to the Moon, space colonists will not be able to rely on deliveries of air, water, and food from Earth; instead they will have to live off the land. They’ll have to create Earth-like environments with consumables derived from local materials and recycled the way that air, water, and things that we eat are replenished on our home world.

The lack of technology for such sustainable life support systems is a major factor underlying criticism of human space exploration. And it’s not the only factor. There’s also the high cost of human space flight and the substantial risk to human life. Weighed against the staggering advances in computers, robots, and nanotechnology, the argument for sending astronauts to explore space instead of robot probes seems weak, except when one more issue is added to the equation: extinction insurance against planet-wide disasters caused either by nature, or by our own negligence.

Louis Friedman, a space policy expert and astronautical engineer, embraces both the pro-human and pro-robot perspective in his book. He does this by arguing that off-world colonization will be needed, and therefore accomplished soon, to assure long-term survival of humanity, with Mars as the chosen location for our second home. But when it comes to exploration deeper into space, Friedman believes we’ll opt to leave that task to our robot emissaries. The reason, which he outlined in an interview with this writer for Discover Magazine, is that technology — including biotechnology that will enable uploading of the visual, audio, and other sensory experiences of our robot explorers to the human brain — will make virtual travel to distant locations better than the real thing, so why put the fragile human body at so much risk?

How much risk is acceptable may be a matter of opinion, but in addition to making a virtual space exploration experience, biotechnology also could reduce the risk to humans who do choose to travel through space physically. In a paper published in the Journal of the Royal Society, University of California, Berkeley aerospace engineer and synthetic biology researcher Amor Menezes suggested six key challenges to establishing a human space presence that could be addressed with synthetic biology.

Synthetic biology and the challenges of space colonization

The first challenge, Menezes and his colleagues explain, is resource utilization. Unlike the Pilgrims on the shores of America, early colonists on the Moon or Mars will not be able to get their dinner by going fishing, but they could make the lunar or Martian dirt into soil for growing plants. The Moon has water in the form of ice that they could melt and both water and the lunar rocks contain oxygen that can be drawn out through electrochemical reactions. Rather than discard the carbon dioxide that humans exhale as is done on spacecraft, colonists could use the waste gas as a carbon source for making food. We already have organisms that do this. They include plants and photosynthetic bacteria, but genetic engineering has been making the carbon fixation process to create food more efficient, and future modification could be tailored to make optimize photosynthesis for the dirt and environments of the Moon and Mars. In addition to food production, organisms can also be engineered to convert Martian and lunar materials into fuel that could be used for rockets, and finally the organisms could be used to process waste.

In addition to using locally derived resources, space colonists will need to engage in massive manufacturing. Menezes believes that organisms could be engineered to produce biocement, biopolymers, adhesives, and other building materials. By recycling air and water, processing solid wastes, and producing food, genetically modified organisms could also play a central role in life support systems, which the paper lists as the third challenge for a long-term human space presence.

As for the fourth challenge, the researchers discuss space medicine and human health applications. Examples of how genetic engineering can help in this area include onsite synthesis of drugs, a capability that will be vital to colonizations, since drugs are vulnerable to radiation, making the prospect of transporting medicines from Earth unattractive. At the same time, modified organisms might also be developed to create radiation-resistant clothing and other bioshielding material.

Space cybernetics is the fifth challenge. For reasons similar to the drug manufacture issue, space colonists will be better off making their own electronics rather than depending on electronics shipped from Earth, and biosynthetic approaches could be the right tactic.

The final challenge, one that Menezes and the team admits is the most difficult, is called terraforming. Whether on the Moon, Mars, or even an asteroid, living inside a pressurized module won’t be satisfying for more than a short bout. For long-term residence, humans will need environments that look and feel natural, with plenty of trees, parkland, and rivers and streams in order to thrive.

The process of converting an entire planet like Mars or Venus into a world with a breathable atmosphere and a comfortable temperature is called terraforming. Scientists think that it could be technically possible, but terraforming an entire Mars-like world would probably take centuries and possibly even millennia. For this reason, space colonization proponents are also considering a less ambitious goal known as paraterraforming, basically terraforming but on a limited area of another world. On the Moon, for instance, a large crater, such as the 21 kilometer wide Shackelton crater on the Moon’s south pole, could be sealed with a dome and the inner environment could be terraformed in just a few years. On Mars, caves could be sealed and terraformed, while a small asteroid could be hollowed out, terraformed on the inside and even spun to create Earth-equivalent gravity. In all of these cases, engineered organisms would be key to the paraformation process. As on Earth, success would be more likely for those willing to start small, and the creation of an Earth-like environment on a small scale would demonstrate that, in the future, it might also be achieved on a planetary scale.

If a long-term human presence on other worlds is the goal, then genetically altered organisms are the key. If this is the case, and if we do decide that extinction insurance makes sense, it would mean that human survival itself depends on the continued development of biotechnology.

#### Getting off the rock solves every existential threat -- failure makes human extinction inevitable

Kaku 18, Dr. Michio Kaku (Professor of theoretical physics in the City College of New York and CUNY Graduate Center, Co-Inventor of String Field Theory, PhD from UC Berkeley). The Future of Humanity: Terraforming Mars, Interstellar Travel, Immortality, and Our Destiny Beyond. Doubleday Publishing. 2018. pp 25-33. WJ

It is as inescapable as the laws of physics that humanity will one day confront some type of extinction-level event. But will we, like our ancestors, have the drive and determination to survive and even flourish?

If we scan all the life-forms that have ever existed on the Earth, from microscopic bacteria to towering forests, lumbering dinosaurs, and enterprising humans, we find that more than 99.9 percent of them eventually became extinct. This means that extinction is the norm, that the odds are already stacked heavily against us. When we dig beneath our feet into the soil to unearth the fossil record, we see evidence of many ancient life-forms. Yet only the smallest handful survive today. Millions of species have appeared before us; they had their day in the sun, and then they withered and died. That is the story of life.

No matter how much we may treasure the sight of dramatic, romantic sunsets, the smell of fresh ocean breezes, and the warmth of a summer’s day, one day it will all end, and the planet will become inhospitable to human life. Nature will eventually turn on us, as it did to all those extinct life-forms.

The grand history of life on Earth shows that, faced with a hostile environment, organisms inevitably meet one of three fates. They can leave that environment, they can adapt to it, or they will die. But if we look far enough into the future, we will eventually face a disaster so great that adaptation will be virtually impossible. Either we must leave the Earth or we will perish. There is no other way.

These disasters have happened repeatedly in the past, and they will inevitably happen in the future. The Earth has already sustained five major extinction cycles, in which up to 90 percent of all life-forms vanished from the Earth. As sure as day follows night, there will be more to come.

On a scale of decades, we face threats that are not natural but are largely self-inflicted, due to our own folly and shortsightedness. We face the danger of global warming, when the atmosphere of the Earth itself turns against us. We face the danger of modern warfare, as nuclear weapons proliferate in some of the most unstable regions of the globe. We face the danger of weaponized microbes, such as airborne AIDS or Ebola, which can be transmitted by a simple cough or sneeze. This could wipe out upward of 98 percent of the human race. Furthermore, we face an expanding population that consumes resources at a furious rate. We may exceed the carrying capacity of Earth at some point and find ourselves in an ecological Armageddon, vying for the planet’s last remaining supplies.

In addition to calamities that we create ourselves, there are also natural disasters over which we have little control. On a scale of thousands of years, we face the onset of another ice age. For the past one hundred thousand years, much of Earth’s surface was blanketed by up to a half mile of solid ice. The bleak frozen landscape drove many animals to extinction. Then, ten thousand years ago, there was a thaw in the weather. This brief warming spell led to the sudden rise of modern civilization, and humans have taken advantage of it to spread and thrive. But this flowering has occurred during an interglacial period, meaning we will likely meet another ice age within the next ten thousand years. When it comes, our cities will disappear under mountains of snow and civilization will be crushed under the ice.

We also face the possibility that the supervolcano under Yellowstone National Park may awaken from its long slumber, tearing the United States apart and engulfing the Earth in a choking, poisonous cloud of soot and debris. Previous eruptions took place 630,000, 1.3 million, and 2.1 million years ago. Each event was separated by roughly 700,000 years; therefore, we may be due for another colossal eruption in the next 100,000 years.

On a scale of millions of years, we face the threat of another meteor or cometary impact, similar to the one that helped to destroy the dinosaurs 65 million years ago. Back then, a rock about six miles across plunged into the Yucatán peninsula of Mexico, sending into the sky fiery debris that rained back on Earth. As with the explosion at Toba, only much larger, the ash clouds eventually darkened the sun and led temperatures to plunge globally. With the withering of vegetation, the food chain collapsed. Plant-eating dinosaurs starved to death, followed soon by their carnivorous cousins. In the end, 90 percent of all life-forms on Earth perished in the wake of this catastrophic event.

For millennia, we have been blissfully ignorant of the reality that the Earth is floating in a swarm of potentially deadly rocks. Only within the last decade have scientists begun to quantify the real risk of a major impact. We now know that there are several thousand NEOs (near-Earth objects) that cross the orbit of the Earth and pose a danger to life on our planet. As of June 2017, 16,294 of these objects have been catalogued. But these are just the ones we’ve found. Astronomers estimate that there are perhaps several million uncharted objects in the solar system that pass by the Earth.

I once interviewed the late astronomer Carl Sagan about this threat. He stressed to me that “we live in a cosmic shooting gallery,” surrounded by potential hazards. It is only a matter of time, he told me, before a large asteroid hits the Earth. If we could somehow illuminate these asteroids, we would see the night sky filled with thousands of menacing points of light.

Even assuming we avoid all these dangers, there is another that dwarfs all the others. Five billion years from now, the sun will expand into a giant red star that fills the entire sky. The sun will be so gigantic that the orbit of the Earth will be inside its blazing atmosphere, and the blistering heat will make life impossible within this inferno.

Unlike all other life-forms on this planet, which must passively await their fate, we humans are masters of our own destiny. Fortunately, we are now creating the tools that will defy the odds given to us by nature, so that we don’t become one of the 99.9 percent of life-forms destined for extinction. In this book, we will encounter the pioneers who have the energy, the vision, and the resources to change the fate of humanity. We will meet the dreamers who believe that humanity can live and thrive in outer space. We will analyze the revolutionary advances in technology that will make it possible to leave the Earth and to settle elsewhere in the solar system, and even beyond.

But if there is one lesson we can learn from our history, it is that humanity, when faced with life-threatening crises, has risen to the challenge and has reached for even higher goals. In some sense, the spirit of exploration is in our genes and hardwired into our soul.

But now we face perhaps the greatest challenge of all: to leave the confines of the Earth and soar into outer space. The laws of physics are clear; sooner or later we will face global crises that threaten our very existence.

Life is too precious to be placed on a single planet, to be at the mercy of these planetary threats.

We need an insurance policy, Sagan told me. He concluded that we should become a “two planet species.” In other words, we need a backup plan.

In this book, we will explore the history, the challenges, and the possible solutions that lie before us. The path will not be easy, and there will be setbacks, but we have no choice.

### 1AC – Plan

#### Plan – The member nations of the World Trade Organization ought to reduce intellectual property protections for synthetic biology

#### Patents on synthetic biology undermine innovation and prevent growth of industry.

**Rai and Boyle 7** [Arti Rai and James Boyle, Arti K. Rai Elvin R. Latty Professor of Law 919-613-7276 Rai@law.duke.edu Room: 3190 Assistant: Leanna Doty Arti Rai, Elvin R. Latty Professor of Law and Faculty Director, The Center for Innovation Policy at Duke Law, is an internationally recognized expert in intellectual property (IP) law, innovation policy, administrative law, and health law. Rai's extensive research on these subjects has been funded by NIH, NSF, Arnold Ventures, the Kauffman Foundation, the Greenwall Foundation, and the Woodrow Wilson Center. Ai currently serves as a Senior Advisor on innovation-related law and policy issues to the Department of Commerce’s Office of General Counsel. She also regularly advises other federal and state agencies as well as Congress on these issues. She is a member of multiple distinguished councils, including the National Academies’ Forum on Drug Discovery, Development, and Translation, the Polaris Advisory Council to the Government Accountability Office, and the American Law Institute. She has also served as a member of the National Advisory Council for Human Genome Research, as a public member of the Administrative Conference of the United States, and on numerous National Academies committees. From 2009-2010, Rai headed the Office of Policy and International Affairs at the U.S. Patent and Trademark Office (USPTO). In that capacity, she led policy analysis of the patent reform legislation that ultimately became the America Invents Act and worked to establish the USPTO’s Office of the Chief Economist. Prior to entering academia, Rai clerked in the Northern District of California and was a litigator at Jenner & Block and the Department of Justice. Rai graduated from Harvard College, magna cum laude, with a degree in biochemistry and history (history and science), attended Harvard Medical School for the 1987-1988 academic year, and received her J.D., cum laude, from Harvard Law School in 1991. , James Boyle is William Neal Reynolds Professor of Law and co-founder of the Center for the Study of the Public Domain at Duke Law School. He joined the faculty in July 2000. He has also taught at American University, Yale, Harvard, and the University of Pennsylvania Law School. 3-13-2007, accessed on 9-11-2021, PubMed Central (PMC), "Synthetic Biology: Caught between Property Rights, the Public Domain, and the Commons", <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1821064/>] Adam

The specter of broad patents has already reared its head in the field of synthetic biology. Consider patent 6,774,222, issued by the US Patent and Trademark Office on August 10, 2004 [15]. The patent, issued to the US Department of Health and Human Services (HHS), is entitled “Molecular Computing Elements, Gates and FlipFlops.” This patent covers using the combination of nucleic-acid binding proteins and nucleic acids to set up data storage as well as logic gates that perform basic Boolean algebra. As the patent document notes, the invention could be used not only for computation but also for complex (“digital”) control of gene expression. The broadest claim does not limit itself to any particular set of nuclei-acid binding proteins or nucleic acids. Moreover, the claim uses language that would cover not only the “parts” that performed the Boolean algebra but also any device and system that contained these parts. Such a patent would seem effectively to patent the basic functions of computing when implemented by one likely genetic means. Would such a foundational patent hold up in court? Given the low nonobviousness threshold that the Federal Circuit has set in the area of biotechnology, there is some possibility that the court would apply a similarly low threshold here. The Federal Circuit’s reluctance to allow unwritten knowledge to be used in determining nonobviousness may also impose a low threshold. Thus, even if, at the time the HHS invention was made, individuals working in the field knew that many computing functions could readily be performed using DNAbased “genetic switches,” this unwritten knowledge might not be factored into the nonobviousness determination. Notably, the HHS patent is not unique in its breadth [16,17]. Considerable historical evidence, including evidence from virtually every important industry of the 20th century, suggests that broad patents on foundational research can slow growth in the industry [18]. In the area of computer hardware, the specter of broad patents loomed large in the US until government action forced licensing of the AT&T transistor patent as well as patents obtained by Texas Instruments and Fairchild Instruments on integrated circuits. Fortunately, software was already a robust industry before broad software patents became available. Biotechnology’s foundational technologies—monoclonal antibodies and recombinant techniques—either were not patented or were made available widely at reasonable cost. Synthetic biology may be coming of age under different circumstances, at the juncture of two technologies with which the law is already struggling. To be sure, to the extent that foundational patents are held by universities or government institutions, they may not be asserted aggressively so as to block research. However, in addition to the problem of broad foundational patents, there is the possibility of a plethora of narrower patents (some of which may fall within the scope of the foundational patents). For example, scientists at Boston University have filed patents that claim the use of DNA to produce specific gene regulation mechanisms such as a multi-state oscillator [19–21]. MIT and the company Sangamo have patents on various types of DNA binding proteins. At least in the area of information technology, there is evidence that patent thickets [22] or “anti-commons” [23] create difficulties for subsequent researchers above and beyond those created by foundational patents. (The situation in biotechnology is less clear; compare [24] and [25].) This is because many products in information technology represent combinations of dozens, if not hundreds, of patented parts. Not only does a crowded patent landscape create the possibility of “hold up” by a previously unknown patent holder who emerges only after others have invested large sums of money in the area of the patented invention, but to the extent that patent rights holders rely upon reach through royalties to secure revenue, standard economic theory predicts that product output by the improver will be suboptimal. Moreover, while firms that work in information technology have sometimes succeeded in pooling patents, particularly patents around industry standards, such efforts have also been stymied by failure on the part of participating firms to disclose relevant patents [26]. In any event, because synthetic biology encompasses not only information technology but also biotechnology, the absence of successful patent pools in the life sciences is cause for concern.

#### Status quo protections prevent innovation & incentivize intervention through lawsuits.

Contreras, et al, 15 [Jorge L. Contreras, S.J. Quinney College of Law and Department of Human Genetics, University of Utah; Arti K. Rai, Professor of Law, Duke Law School. Faculty Associate, Duke Institute for Genome Sciences & Policy; Andrew W. Torrance, School of Law, University of Kansas, January 2015, NatureBiotechnology, “Intellectual property issues and synthetic biology standards,” vol 33, number 1, pg. 1-2, doi: 10.1038/nbt.3107, accessed 8-17-2021]JMK

We commend Galdzicki et al.1 on their development of the Synthetic Biology Open Language (SBOL), as described in the June 2014 issue. The technical standards being developed by such groups are much-needed mechanisms for enabling collaboration by diverse research organizations, for accelerating scientific progress in synthetic biology and for the eventual commercialization of resulting technologies. We were surprised, however, to see no mention of intellectual property (IP) or other legal issues pertaining to the use and deployment of SBOL or other synthetic biology standards. Although we understand that the focus of Galdzicki’s article was primarily technical, legal issues today are inextricably entwined with standards that enable product and process interoperability. Certainly, the authors acknowledged the prevalence of standards in “every engineering field,” but they overlooked the legal issues that have bedeviled standards developers over the past two decades in industries ranging from wireless telecommunications to computer networking to semiconductor memory.

Patents, in particular, have posed challenges to standards developers and implementers in the information and communications technology (ICT) sector. Disputes can arise when a participant in the standards-development process holds patents covering the standard and then seeks to charge unanticipated royalties on products that conform to the standard. To address these risks, the rules of most ICT standards development organizations require that such patents be disclosed and/or licensed to implementers of their standards2. These rules may require that licenses be either royalty-free or royaltybearing on terms that are “fair, reasonable and nondiscriminatory” (FRAND). Although significant disagreement remains regarding the interpretation of FRAND and other standards-related commitments3,4, a vast amount of standardization occurs in the ICT sector under such policies.

Although the biological sciences have remained largely unaffected by the standards litigation that has plagued the ICT sector4, there is no unique structural feature that immunizes biomedical and other bioscience standards from such disputes5. It is wellknown that universities and other research institutions have acquired substantial patent assets, as have private sector biotech and pharmaceutical companies6. Patents have pervaded synthetic biology from the outset7, and they are playing an increasingly important role in its development8. As such, it is not hard to envision a scenario in which patents may cover one or more key aspects of synthetic biology standards, such as SBOL, immediately confronting the field with the prospect of unanticipated royalty payments. Indeed, it is possible that biotech “patent assertion entities” may emerge to enforce synthetic biology patent portfolios.

We consider it vital for standards-setting initiatives in synthetic biology, like SBOL, to address several questions. Has any effort been made to determine whether such patents exist? Are participants in SBOL standardization activities required or encouraged to disclose patents that they may obtain on standardized technologies? If such patents are obtained, what rules will govern the terms on which such patents will be made available to the community?

We are concerned that the synthetic biology scientific community is not prepared for the eventual emergence of patents affecting synthetic biology standards, and that this young community may thus be vulnerable to opportunism by unscrupulous actors. But all is not lost. Indeed, the synthetic biology community has enthusiastically adopted an ethos of contributing standardized biological components, such as BioBrick parts, to the community free from patent encumbrances (https://biobricks.org/bpa/). It would be a small step to implement similar policies for synthetic biology standards, such as SBOL. Such an approach has recently been proposed by one of us for bioinformatics standards9, and numerous readily available tools exist to assist with policy development2. Best outcomes for synthetic biology will result from simultaneous consideration of technical standards and IP issues.

### 1AC – Framing

#### The standard is maximizing expected wellbeing or act hedonistic util.

#### Prefer:

#### 1] Pleasure and pain *are* intrinsic value and disvalue – everything else *regresses* – robust neuroscience.

Blum et al. 18

Kenneth Blum, 1Department of Psychiatry, Boonshoft School of Medicine, Dayton VA Medical Center, Wright State University, Dayton, OH, USA 2Department of Psychiatry, McKnight Brain Institute, University of Florida College of Medicine, Gainesville, FL, USA 3Department of Psychiatry and Behavioral Sciences, Keck Medicine University of Southern California, Los Angeles, CA, USA 4Division of Applied Clinical Research & Education, Dominion Diagnostics, LLC, North Kingstown, RI, USA 5Department of Precision Medicine, Geneus Health LLC, San Antonio, TX, USA 6Department of Addiction Research & Therapy, Nupathways Inc., Innsbrook, MO, USA 7Department of Clinical Neurology, Path Foundation, New York, NY, USA 8Division of Neuroscience-Based Addiction Therapy, The Shores Treatment & Recovery Center, Port Saint Lucie, FL, USA 9Institute of Psychology, Eötvös Loránd University, Budapest, Hungary 10Division of Addiction Research, Dominion Diagnostics, LLC. North Kingston, RI, USA 11Victory Nutrition International, Lederach, PA., USA 12National Human Genome Center at Howard University, Washington, DC., USA, Marjorie Gondré-Lewis, 12National Human Genome Center at Howard University, Washington, DC., USA 13Departments of Anatomy and Psychiatry, Howard University College of Medicine, Washington, DC US, Bruce Steinberg, 4Division of Applied Clinical Research & Education, Dominion Diagnostics, LLC, North Kingstown, RI, USA, Igor Elman, 15Department Psychiatry, Cooper University School of Medicine, Camden, NJ, USA, David Baron, 3Department of Psychiatry and Behavioral Sciences, Keck Medicine University of Southern California, Los Angeles, CA, USA, Edward J Modestino, 14Department of Psychology, Curry College, Milton, MA, USA, Rajendra D Badgaiyan, 15Department Psychiatry, Cooper University School of Medicine, Camden, NJ, USA, Mark S Gold 16Department of Psychiatry, Washington University, St. Louis, MO, USA, “Our evolved unique pleasure circuit makes humans different from apes: Reconsideration of data derived from animal studies”, U.S. Department of Veterans Affairs, 28 February 2018, accessed: 19 August 2020, <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6446569/>, R.S.

**Pleasure** is not only one of the three primary reward functions but it also **defines reward.** As homeostasis explains the functions of only a limited number of rewards, the principal reason why particular stimuli, objects, events, situations, and activities are rewarding may be due to pleasure. This applies first of all to sex and to the primary homeostatic rewards of food and liquid and extends to money, taste, beauty, social encounters and nonmaterial, internally set, and intrinsic rewards. Pleasure, as the primary effect of rewards, drives the prime reward functions of learning, approach behavior, and decision making and provides the **basis for hedonic theories** of reward function. We are attracted by most rewards and exert intense efforts to obtain them, just because they are enjoyable [10].

Pleasure is a passive reaction that derives from the experience or prediction of reward and may lead to a long-lasting state of happiness. The word happiness is difficult to define. In fact, just obtaining physical pleasure may not be enough. One key to happiness involves a network of good friends. However, it is not obvious how the higher forms of satisfaction and pleasure are related to an ice cream cone, or to your team winning a sporting event. Recent multidisciplinary research, using both humans and detailed invasive brain analysis of animals has discovered some critical ways that the brain processes pleasure [14].

Pleasure as a hallmark of reward is sufficient for defining a reward, but it may not be necessary. A reward may generate positive learning and approach behavior simply because it contains substances that are essential for body function. When we are hungry, we may eat bad and unpleasant meals. A monkey who receives hundreds of small drops of water every morning in the laboratory is unlikely to feel a rush of pleasure every time it gets the 0.1 ml. Nevertheless, with these precautions in mind, we may define any stimulus, object, event, activity, or situation that has the potential to produce pleasure as a reward. In the context of reward deficiency or for disorders of addiction, homeostasis pursues pharmacological treatments: drugs to treat drug addiction, obesity, and other compulsive behaviors. The theory of allostasis suggests broader approaches - such as re-expanding the range of possible pleasures and providing opportunities to expend effort in their pursuit. [15]. It is noteworthy, the first animal studies eliciting approach behavior by electrical brain stimulation interpreted their findings as a discovery of the brain’s pleasure centers [16] which were later partly associated with midbrain dopamine neurons [17–19] despite the notorious difficulties of identifying emotions in animals.

Evolutionary theories of pleasure: The love connection BO:D

Charles Darwin and other biological scientists that have examined the biological evolution and its basic principles found various mechanisms that steer behavior and biological development. Besides their theory on natural selection, it was particularly the sexual selection process that gained significance in the latter context over the last century, especially when it comes to the question of what makes us “what we are,” i.e., human. However, the capacity to sexually select and evolve is not at all a human accomplishment alone or a sign of our uniqueness; yet, we humans, as it seems, are ingenious in fooling ourselves and others–when we are in love or desperately search for it.

It is well established that modern biological theory conjectures that **organisms are** the **result of evolutionary competition.** In fact, Richard Dawkins stresses gene survival and propagation as the basic mechanism of life [20]. Only genes that lead to the fittest phenotype will make it. It is noteworthy that the phenotype is selected based on behavior that maximizes gene propagation. To do so, the phenotype must survive and generate offspring, and be better at it than its competitors. Thus, the ultimate, distal function of rewards is to increase evolutionary fitness by ensuring the survival of the organism and reproduction. It is agreed that learning, approach, economic decisions, and positive emotions are the proximal functions through which phenotypes obtain other necessary nutrients for survival, mating, and care for offspring.

Behavioral reward functions have evolved to help individuals to survive and propagate their genes. Apparently, people need to live well and long enough to reproduce. Most would agree that homo-sapiens do so by ingesting the substances that make their bodies function properly. For this reason, foods and drinks are rewards. Additional rewards, including those used for economic exchanges, ensure sufficient palatable food and drink supply. Mating and gene propagation is supported by powerful sexual attraction. Additional properties, like body form, augment the chance to mate and nourish and defend offspring and are therefore also rewards. Care for offspring until they can reproduce themselves helps gene propagation and is rewarding; otherwise, many believe mating is useless. According to David E Comings, as any small edge will ultimately result in evolutionary advantage [21], additional reward mechanisms like novelty seeking and exploration widen the spectrum of available rewards and thus enhance the chance for survival, reproduction, and ultimate gene propagation. These functions may help us to obtain the benefits of distant rewards that are determined by our own interests and not immediately available in the environment. Thus the distal reward function in gene propagation and evolutionary fitness defines the proximal reward functions that we see in everyday behavior. That is why foods, drinks, mates, and offspring are rewarding.

There have been theories linking pleasure as a required component of health benefits salutogenesis, (salugenesis). In essence, under these terms, pleasure is described as a state or feeling of happiness and satisfaction resulting from an experience that one enjoys. Regarding pleasure, it is a double-edged sword, on the one hand, it promotes positive feelings (like mindfulness) and even better cognition, possibly through the release of dopamine [22]. But on the other hand, pleasure simultaneously encourages addiction and other negative behaviors, i.e., motivational toxicity. It is a complex neurobiological phenomenon, relying on reward circuitry or limbic activity. It is important to realize that through the “Brain Reward Cascade” (BRC) endorphin and endogenous morphinergic mechanisms may play a role [23]. While natural rewards are essential for survival and appetitive motivation leading to beneficial biological behaviors like eating, sex, and reproduction, crucial social interactions seem to further facilitate the positive effects exerted by pleasurable experiences. Indeed, experimentation with addictive drugs is capable of directly acting on reward pathways and causing deterioration of these systems promoting hypodopaminergia [24]. Most would agree that pleasurable activities can stimulate personal growth and may help to induce healthy behavioral changes, including stress management [25]. The work of Esch and Stefano [26] concerning the link between compassion and love implicate the brain reward system, and pleasure induction suggests that social contact in general, i.e., love, attachment, and compassion, can be highly effective in stress reduction, survival, and overall health.

Understanding the role of neurotransmission and pleasurable states both positive and negative have been adequately studied over many decades [26–37], but comparative anatomical and neurobiological function between animals and homo sapiens appear to be required and seem to be in an infancy stage.

Finding happiness is different between apes and humans

As stated earlier in this expert opinion one key to happiness involves a network of good friends [38]. However, it is not entirely clear exactly how the higher forms of satisfaction and pleasure are related to a sugar rush, winning a sports event or even sky diving, all of which augment dopamine release at the reward brain site. Recent multidisciplinary research, using both humans and detailed invasive brain analysis of animals has discovered some critical ways that the brain processes pleasure.

Remarkably, there are pathways for ordinary liking and pleasure, which are limited in scope as described above in this commentary. However, there are **many brain regions**, often termed hot and cold spots, that significantly **modulate** (increase or decrease) our **pleasure or** even produce **the opposite** of pleasure— that is disgust and fear [39]. One specific region of the nucleus accumbens is organized like a computer keyboard, with particular stimulus triggers in rows— producing an increase and decrease of pleasure and disgust. Moreover, the cortex has unique roles in the cognitive evaluation of our feelings of pleasure [40]. Importantly, the interplay of these multiple triggers and the higher brain centers in the prefrontal cortex are very intricate and are just being uncovered.

Desire and reward centers

It is surprising that many different sources of pleasure activate the same circuits between the mesocorticolimbic regions (Figure 1). Reward and desire are two aspects pleasure induction and have a very widespread, large circuit. Some part of this circuit distinguishes between desire and dread. The so-called pleasure circuitry called “REWARD” involves a well-known dopamine pathway in the mesolimbic system that can influence both pleasure and motivation.

In simplest terms, the well-established mesolimbic system is a dopamine circuit for reward. It starts in the ventral tegmental area (VTA) of the midbrain and travels to the nucleus accumbens (Figure 2). It is the cornerstone target to all addictions. The VTA is encompassed with neurons using glutamate, GABA, and dopamine. The nucleus accumbens (NAc) is located within the ventral striatum and is divided into two sub-regions—the motor and limbic regions associated with its core and shell, respectively. The NAc has spiny neurons that receive dopamine from the VTA and glutamate (a dopamine driver) from the hippocampus, amygdala and medial prefrontal cortex. Subsequently, the NAc projects GABA signals to an area termed the ventral pallidum (VP). The region is a relay station in the limbic loop of the basal ganglia, critical for motivation, behavior, emotions and the “Feel Good” response. This defined system of the brain is involved in all addictions –substance, and non –substance related. In 1995, our laboratory coined the term “Reward Deficiency Syndrome” (RDS) to describe genetic and epigenetic induced hypodopaminergia in the “Brain Reward Cascade” that contribute to addiction and compulsive behaviors [3,6,41].

Furthermore, ordinary “liking” of something, or pure pleasure, is represented by small regions mainly in the limbic system (old reptilian part of the brain). These may be part of larger neural circuits. In Latin, hedus is the term for “sweet”; and in Greek, hodone is the term for “pleasure.” Thus, the word Hedonic is now referring to various subcomponents of pleasure: some associated with purely sensory and others with more complex emotions involving morals, aesthetics, and social interactions. The capacity to have pleasure is part of being healthy and may even extend life, especially if linked to optimism as a dopaminergic response [42].

Psychiatric illness often includes symptoms of an abnormal inability to experience pleasure, referred to as anhedonia. A negative feeling state is called dysphoria, which can consist of many emotions such as pain, depression, anxiety, fear, and disgust. Previously many scientists used animal research to uncover the complex mechanisms of pleasure, liking, motivation and even emotions like panic and fear, as discussed above [43]. However, as a significant amount of related research about the specific brain regions of pleasure/reward circuitry has been derived from invasive studies of animals, these cannot be directly compared with subjective states experienced by humans.

In an attempt to resolve the controversy regarding the causal contributions of mesolimbic dopamine systems to reward, we have previously evaluated the three-main competing explanatory categories: “liking,” “learning,” and “wanting” [3]. That is, dopamine may mediate (a) liking: the hedonic impact of reward, (b) learning: learned predictions about rewarding effects, or (c) wanting: the pursuit of rewards by attributing incentive salience to reward-related stimuli [44]. We have evaluated these hypotheses, especially as they relate to the RDS, and we find that the incentive salience or “wanting” hypothesis of dopaminergic functioning is supported by a majority of the scientific evidence. Various neuroimaging studies have shown that anticipated behaviors such as sex and gaming, delicious foods and drugs of abuse all affect brain regions associated with reward networks, and may not be unidirectional. Drugs of abuse enhance dopamine signaling which sensitizes mesolimbic brain mechanisms that apparently evolved explicitly to attribute incentive salience to various rewards [45].

Addictive substances are voluntarily self-administered, and they enhance (directly or indirectly) dopaminergic synaptic function in the NAc. This activation of the brain reward networks (producing the ecstatic “high” that users seek). Although these circuits were initially thought to encode a set point of hedonic tone, it is now being considered to be far more complicated in function, also encoding attention, reward expectancy, disconfirmation of reward expectancy, and incentive motivation [46]. The argument about addiction as a disease may be confused with a predisposition to substance and nonsubstance rewards relative to the extreme effect of drugs of abuse on brain neurochemistry. The former sets up an individual to be at high risk through both genetic polymorphisms in reward genes as well as harmful epigenetic insult. Some Psychologists, even with all the data, still infer that addiction is not a disease [47]. Elevated stress levels, together with polymorphisms (genetic variations) of various dopaminergic genes and the genes related to other neurotransmitters (and their genetic variants), and may have an additive effect on vulnerability to various addictions [48]. In this regard, Vanyukov, et al. [48] suggested based on review that whereas the gateway hypothesis does not specify mechanistic connections between “stages,” and does not extend to the risks for addictions the concept of common liability to addictions may be more parsimonious. The latter theory is grounded in genetic theory and supported by data identifying common sources of variation in the risk for specific addictions (e.g., RDS). This commonality has identifiable neurobiological substrate and plausible evolutionary explanations.

Over many years the controversy of dopamine involvement in especially “pleasure” has led to confusion concerning separating motivation from actual pleasure (wanting versus liking) [49]. We take the position that animal studies cannot provide real clinical information as described by self-reports in humans. As mentioned earlier and in the abstract, on November 23rd, 2017, evidence for our concerns was discovered [50]

In essence, although nonhuman primate brains are similar to our own, the disparity between other primates and those of human cognitive abilities tells us that surface similarity is not the whole story. Sousa et al. [50] small case found various differentially expressed genes, to associate with pleasure related systems. Furthermore, the dopaminergic interneurons located in the human neocortex were absent from the neocortex of nonhuman African apes. Such differences in neuronal transcriptional programs may underlie a variety of neurodevelopmental disorders.

In simpler terms, the system controls the production of dopamine, a chemical messenger that plays a significant role in pleasure and rewards. The senior author, Dr. Nenad Sestan from Yale, stated: “Humans have evolved a dopamine system that is different than the one in chimpanzees.” This may explain why the behavior of humans is so unique from that of non-human primates, even though our brains are so surprisingly similar, Sestan said: “It might also shed light on why people are vulnerable to mental disorders such as autism (possibly even addiction).” Remarkably, this research finding emerged from an extensive, multicenter collaboration to compare the brains across several species. These researchers examined 247 specimens of neural tissue from six humans, five chimpanzees, and five macaque monkeys. Moreover, these investigators analyzed which genes were turned on or off in 16 regions of the brain. While the differences among species were subtle, **there was** a **remarkable contrast in** the **neocortices**, specifically in an area of the brain that is much more developed in humans than in chimpanzees. In fact, these researchers found that a gene called tyrosine hydroxylase (TH) for the enzyme, responsible for the production of dopamine, was expressed in the neocortex of humans, but not chimpanzees. As discussed earlier, dopamine is best known for its essential role within the brain’s reward system; the very system that responds to everything from sex, to gambling, to food, and to addictive drugs. However, dopamine also assists in regulating emotional responses, memory, and movement. Notably, abnormal dopamine levels have been linked to disorders including Parkinson’s, schizophrenia and spectrum disorders such as autism and addiction or RDS.

Nora Volkow, the director of NIDA, pointed out that one alluring possibility is that the neurotransmitter dopamine plays a substantial role in humans’ ability to pursue various rewards that are perhaps months or even years away in the future. This same idea has been suggested by Dr. Robert Sapolsky, a professor of biology and neurology at Stanford University. Dr. Sapolsky cited evidence that dopamine levels rise dramatically in humans when we anticipate potential rewards that are uncertain and even far off in our futures, such as retirement or even the possible alterlife. This may explain what often motivates people to work for things that have no apparent short-term benefit [51]. In similar work, Volkow and Bale [52] proposed a model in which dopamine can favor NOW processes through phasic signaling in reward circuits or LATER processes through tonic signaling in control circuits. Specifically, they suggest that through its modulation of the orbitofrontal cortex, which processes salience attribution, dopamine also enables shilting from NOW to LATER, while its modulation of the insula, which processes interoceptive information, influences the probability of selecting NOW versus LATER actions based on an individual’s physiological state. This hypothesis further supports the concept that disruptions along these circuits contribute to diverse pathologies, including obesity and addiction or RDS.

#### 2] Death is bad and outweighs – a) agents can’t act if they fear for their bodily security which constrains every ethical theory, b) it destroys the subject itself – kills any ability to achieve value in ethics since life is a prerequisite which means it’s a side constraint since we can’t reach the end goal of ethics without life

#### 3] Actor spec—governments must use util because they don’t have intentions and are constantly dealing with tradeoffs—outweighs since different agents have different obligations—takes out calc indicts since they are empirically denied.

#### 4] Reject calc indicts –

#### A] Empirically denied—both individuals and policymakers carry out effective cost-benefit analysis which means even if decisions aren’t always perfect it’s still better than not acting at all

#### B] Theory—they’re functionally NIBs that everyone knows are silly but skew the aff and move the debate away from the topic and actual philosophical debate, killing valuable education

#### 5] Reducing existential risks is the top priority in any coherent moral theory

Plummer 15 (Theron, Philosophy @St. Andrews http://blog.practicalethics.ox.ac.uk/2015/05/moral-agreement-on-saving-the-world/)

There appears to be lot of disagreement in moral philosophy. Whether these many apparent disagreements are deep and irresolvable, I believe there is at least one thing it is reasonable to agree on right now, whatever general moral view we adopt: that it is very important to reduce the risk that all intelligent beings on this planet are eliminated by an enormous catastrophe, such as a nuclear war. How we might in fact try to reduce such existential risks is discussed elsewhere. My claim here is only that we – whether we’re consequentialists, deontologists, or virtue ethicists – should all agree that we should try to save the world. According to consequentialism, we should maximize the good, where this is taken to be the goodness, from an impartial perspective, of outcomes. Clearly one thing that makes an outcome good is that the people in it are doing well. There is little disagreement here. If the happiness or well-being of possible future people is just as important as that of people who already exist, and if they would have good lives, it is not hard to see how reducing existential risk is easily the most important thing in the whole world. This is for the familiar reason that there are so many people who could exist in the future – there are trillions upon trillions… upon trillions. There are so many possible future people that reducing existential risk is arguably the most important thing in the world, even if the well-being of these possible people were given only 0.001% as much weight as that of existing people. Even on a wholly person-affecting view – according to which there’s nothing (apart from effects on existing people) to be said in favor of creating happy people – the case for reducing existential risk is very strong. As noted in this seminal paper, this case is strengthened by the fact that there’s a good chance that many existing people will, with the aid of life-extension technology, live very long and very high quality lives. You might think what I have just argued applies to consequentialists only. There is a tendency to assume that, if an argument appeals to consequentialist considerations (the goodness of outcomes), it is irrelevant to non-consequentialists. But that is a huge mistake. Non-consequentialism is the view that there’s more that determines rightness than the goodness of consequences or outcomes; it is not the view that the latter don’t matter. Even John Rawls wrote, “All ethical doctrines worth our attention take consequences into account in judging rightness. One which did not would simply be irrational, crazy.” Minimally plausible versions of deontology and virtue ethics must be concerned in part with promoting the good, from an impartial point of view. They’d thus imply very strong reasons to reduce existential risk, at least when this doesn’t significantly involve doing harm to others or damaging one’s character. What’s even more surprising, perhaps, is that even if our own good (or that of those near and dear to us) has much greater weight than goodness from the impartial “point of view of the universe,” indeed even if the latter is entirely morally irrelevant, we may nonetheless have very strong reasons to reduce existential risk. Even egoism, the view that each agent should maximize her own good, might imply strong reasons to reduce existential risk. It will depend, among other things, on what one’s own good consists in. If well-being consisted in pleasure only, it is somewhat harder to argue that egoism would imply strong reasons to reduce existential risk – perhaps we could argue that one would maximize her expected hedonic well-being by funding life extension technology or by having herself cryogenically frozen at the time of her bodily death as well as giving money to reduce existential risk (so that there is a world for her to live in!). I am not sure, however, how strong the reasons to do this would be. But views which imply that, if I don’t care about other people, I have no or very little reason to help them are not even minimally plausible views (in addition to hedonistic egoism, I here have in mind views that imply that one has no reason to perform an act unless one actually desires to do that act). To be minimally plausible, egoism will need to be paired with a more sophisticated account of well-being. To see this, it is enough to consider, as Plato did, the possibility of a ring of invisibility – suppose that, while wearing it, Ayn could derive some pleasure by helping the poor, but instead could derive just a bit more by severely harming them. Hedonistic egoism would absurdly imply she should do the latter. To avoid this implication, egoists would need to build something like the meaningfulness of a life into well-being, in some robust way, where this would to a significant extent be a function of other-regarding concerns (see chapter 12 of this classic intro to ethics). But once these elements are included, we can (roughly, as above) argue that this sort of egoism will imply strong reasons to reduce existential risk. Add to all of this Samuel Scheffler’s recent intriguing arguments (quick podcast version available here) that most of what makes our lives go well would be undermined if there were no future generations of intelligent persons. On his view, my life would contain vastly less well-being if (say) a year after my death the world came to an end. So obviously if Scheffler were right I’d have very strong reason to reduce existential risk. We should also take into account moral uncertainty. What is it reasonable for one to do, when one is uncertain not (only) about the empirical facts, but also about the moral facts? I’ve just argued that there’s agreement among minimally plausible ethical views that we have strong reason to reduce existential risk – not only consequentialists, but also deontologists, virtue ethicists, and sophisticated egoists should agree. But even those (hedonistic egoists) who disagree should have a significant level of confidence that they are mistaken, and that one of the above views is correct. Even if they were 90% sure that their view is the correct one (and 10% sure that one of these other ones is correct), they would have pretty strong reason, from the standpoint of moral uncertainty, to reduce existential risk. Perhaps most disturbingly still, even if we are only 1% sure that the well-being of possible future people matters, it is at least arguable that, from the standpoint of moral uncertainty, reducing existential risk is the most important thing in the world. Again, this is largely for the reason that there are so many people who could exist in the future – there are trillions upon trillions… upon trillions. (For more on this and other related issues, see this excellent dissertation). Of course, it is uncertain whether these untold trillions would, in general, have good lives. It’s possible they’ll be miserable. It is enough for my claim that there is moral agreement in the relevant sense if, at least given certain empirical claims about what future lives would most likely be like, all minimally plausible moral views would converge on the conclusion that we should try to save the world. While there are some non-crazy views that place significantly greater moral weight on avoiding suffering than on promoting happiness, for reasons others have offered (and for independent reasons I won’t get into here unless requested to), they nonetheless seem to be fairly implausible views. And even if things did not go well for our ancestors, I am optimistic that they will overall go fantastically well for our descendants, if we allow them to. I suspect that most of us alive today – at least those of us not suffering from extreme illness or poverty – have lives that are well worth living, and that things will continue to improve. Derek Parfit, whose work has emphasized future generations as well as agreement in ethics, described our situation clearly and accurately: “We live during the hinge of history. Given the scientific and technological discoveries of the last two centuries, the world has never changed as fast. We shall soon have even greater powers to transform, not only our surroundings, but ourselves and our successors. If we act wisely in the next few centuries, humanity will survive its most dangerous and decisive period. Our descendants could, if necessary, go elsewhere, spreading through this galaxy…. Our descendants might, I believe, make the further future very good. But that good future may also depend in part on us. If our selfish recklessness ends human history, we would be acting very wrongly.” (From chapter 36 of On What Matters)