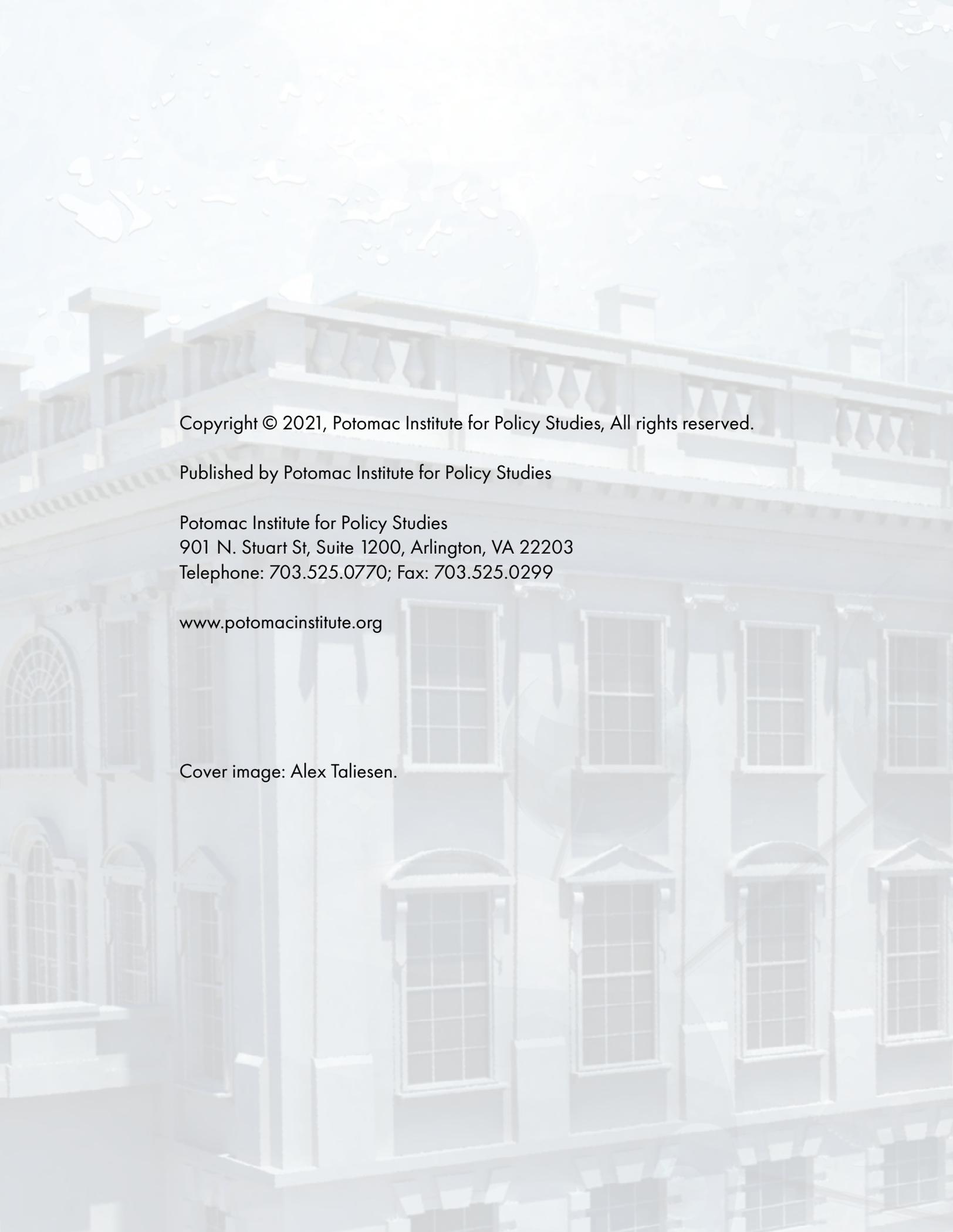


RE-EMBRACE AMERICAN S&T

Reimagine, Reinvent, Restart





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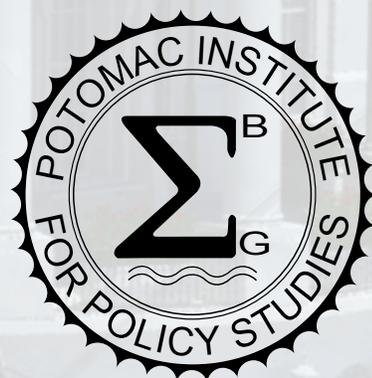
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Cover image: Alex Taliesen.

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INTRODUCTION

The election of a new president offers the country an opportunity to rebuild America with the innovation, inspiration, and leadership that has characterized the nation for two and a half centuries. America has always led the world in technology, new and bold ideas, and an innovative approach to solving problems and meeting challenges. Once again, it is time for the country to re-embrace science and promote American leadership.

The Potomac Institute for Policy Studies was established over twenty years ago during a politically turbulent era. Newt Gingrich and the Republicans had just taken over Congress, written their Contract with America, and dissolved the Office of Technology Assessment (OTA) on the premise that it was too partisan when dealing with science and technology (S&T) policy issues (a decision that has been much debated since). The Potomac Institute was formed to fill the role of a non-partisan, objective, and technically-competent advisor to Congress and the Administration. The Institute—fiercely independent of party—was founded on the principles that 1) science should inform policy and 2) policy should foster the growth of science. The Institute's most important work is anticipating emerging technologies and their associated policy implications, and with this knowledge guiding investments to shape our desired future.

Science and technology have long been the keys to progress in American society. Science and technology have made our military strong, provided for national security, and driven our economy as products and services advanced technologically. Further, the United States has excelled in S&T development by demonstrating the power of the S&T enterprise to protect our nation and drive economic benefits.

The new administration has the opportunity to reinvigorate American leadership, ensuring national security based on superior technology and securing economic benefits based on superior technology and securing economic benefits based on leading scientific discoveries and implementations in the global marketplace. In a tradition of offering bold ideas to a new administration in the area of S&T, we at the Potomac Institute for Policy Studies offer four directions where the new administration can lead the way.

In each of the following four areas, the Potomac Institute for Policy Studies presents background and ideas for action to reinvigorate American S&T. The Institute will provide additional details to implement these ideas in subsequent publications.

1. Inspire, Inform, and Reimagine to Promote American S&T

We must apply S&T leadership to all aspects of American life. We must inspire talented people to continue the American tradition of innovation, ingenuity, and scientific advancement. We cover space travel, data transparency, veracity of information, advanced transportation, programmable manufacturing, and sustainable materials.

2. Rebuild the Infrastructure for American Education

American S&T begins with education and ends with protecting the intellectual property of domestic companies. Reinvigorated infrastructure is required to protect and sustain the S&T enterprise. Issues here include focusing on a new education system inspired by the last year of distance learning and supported by years of research; infrastructure for advancing access to information, which is the heart of education; and bold ideas for government research programs.

3. Capitalize on Biotechnology Advances to Remake Health Care

Changing how we use technology will change the way we provide health care. Sensors, data analytics, and telemedicine will redefine 21st century health care. Precision medicine, bioinformatics, and improved technology for reducing the impact of a pandemic are discussed.

4. Leverage S&T to Reduce the Greatest Risks Confronting Society

Science and technology supports national security, both historically and in the future. The nation faces many threats, both natural and adversarial. We focus on science and technology to address clean energy supply, geoengineering for cleaning the atmosphere, data analytics to improve situational awareness, and cognitive security.

“We ignore public understanding of science at our peril.”

– Eugenie Clark

INSPIRE, INFORM, AND REIMAGINE TO PROMOTE AMERICAN S&T

A prerequisite to maintaining a global leadership position in S&T is public support for the S&T enterprise. Historically, society has appreciated the benefits of S&T, as it has brought security and economic benefits. Generations of American scientists and engineers were inspired by the manned missions to the moon, the introduction of microprocessors and semiconductor electronics, the introduction of personal computers, and the challenges of defense research projects. In America, a certain reverence for S&T has inspired talented people to become scientists and technologists to the benefit of society.

But, it seems that reverence has waned. Distrust of S&T-enabled advancements has spiked, and public support for such investments, particularly fundamental research whose goals are not initially practical, has diminished. Interest in technological feats and scientific advances as reflected in media coverage tends to be minimal. However, there remains a hunger for achievement. For example, the success of the messenger RNA vaccines will certainly inspire new biotechnologists.

It is now time to inspire society with the benefits of S&T. We can do a better job of informing the public and reimagine the possibilities. Renewed global leadership of American S&T will ensue. We suggest a number of programs, initiatives, and research challenges that could help inspire, inform, and enable us to reimagine the benefits of S&T. Such projects could serve to inspire and train future generations of American scientists and re-establish the trust that S&T benefit all of society. It takes leadership to inspire the nation with the benefits and possibilities of new technologies. It takes commitment to translate advancements into goods and services that benefit the world. It builds on a free and open society, where information and opportunities are shared in all communities and science becomes accessible to all.

Space Exploration, to the Moon and Beyond

NASA's project Artemis will again place American astronauts on the Moon in a race to lead in space technology. However, the project could be reimagined as the next step in international space cooperation, beyond the International Space Station, to establish an international lunar habitat. With the purpose of space exploration, we can **Build Back Better** on the moon and beyond. A lunar habitat will be used as a launch point for astronaut health and performance, asteroid and lunar resource mining, and space-based energy production, as well as other potential applications. While continuing pursuit of remotely operated robotic exploration, such human presence would facilitate adaptations that require human ingenuity. Ultimately, a lunar launch point can lead to extensive exploration of the solar system—to Mars and beyond. However, continuous presence in a lunar habitat with resupply shuttles from the Earth and protection from the harms of the space environment by making use of the Moon's resources can teach us much about operating in deep space while providing scientific benefits that redound to Earth inhabitants.

As NASA prepares to expand the reach of human exploration with the goal of sending astronauts to Mars in the 2030s, it will need to leverage advances in terrestrial health care to optimize crew health and performance. A lunar habitat will provide an ideal environment to collect health and performance data and to provide a platform for providing care to space-farers.

The establishment of a lunar habitat will require international diplomatic and treaty negotiations. International cooperation is of great benefit in ensuring the peaceful use of space, and in maintaining friendships throughout the global science and engineering community. American leadership in establishing an international lunar habitat would facilitate cooperation, and benefit all of mankind.

We recommend advancing space exploration through:

- Reimagining the next step in international space cooperation to establish an international lunar habitat. With NASA and other departments, encompassing diplomacy, collaboration, sociology, robotics, medicine, propulsion, materials, mineral science, geology, and all other aspects of international science and technology, focusing on an enduring safe human livable presence on our celestial satellite.



Protect Society Through Transparency and Accountability

We have seen how the prevalence of cell phone cameras, surveillance cameras, microphones, sensors, and local media are able to document activities in public spaces. This ubiquity empowers private individuals to participate in citizen surveillance by documenting evidence that is more reliable than eyewitness accounts. This helps to better protect society by solving crimes, deterring criminal activity, and holding all parties, including law enforcement, accountable.

Law enforcement is often facilitated through forensic analysis of surveillance systems. The Boston Marathon bombing case was solved using videos from personal cell phones and surveillance cameras. Surveillance video also helped locate the perpetrator of the Chelsea bombing in New York City in 2016 through the use of the Domain Awareness System.

Online activities—both public and private—are recorded; location-based services are gathered and sold; and network associations are easily tracked, recorded, and examined. However, not all of these uses are unwanted. Many of these information sources provide desirable and useful functionality, such as location tracking of vehicles, which can help detect traffic jams and shorten commutes.

Forensic use of surveillance information can help combat crime and deter undesired behavior online and offline. Yet, misuse of data by law enforcement, government, or private companies poses threats to ordinary citizens. Criminal behavior and unethical activities should be reduced by invoking transparency and accountability in controlled and appropriate ways.

Sound policies need to be informed by expanding technologies. Such technologies must include capabilities that ensure data veracity and present evidence transparently, while protecting privacy and anonymizing the innocent. Policies and laws concerning data ownership and data use can include ensuring that secure encryption is applied to data not intended for public use, that metadata indicates ownership and access permissions, and provides records of access.

To protect society through transparency and accountability, we recommend the following:

- Establish policies and regulations that protect Americans from malicious use of their data. Develop techniques to analyze data to solve and deter crime with minimal interaction by officials that might otherwise access information about the innocent, ensuring that privacy and data are protected. Develop technologies that assist authorized officials to forensically solve crimes rapidly, while providing technologies that safeguard sensitive data from unauthorized use by malevolent actors.

Information Provenance

The ubiquitous access to the Internet and the availability of user-generated content platforms have led to an era of distrust in institutional knowledge and technical expertise. Though promising a regime of constant and unrestricted access to information at its outset, social media and the Internet at large have allowed for the dissemination and propagation of misleading and misguiding information. The cacophony of disinformation often crowds out the truth, and validation and verification of published information is difficult. People consume media at lightning speed; an automated system will provide the pace required to authenticate information.

An educated and informed population provides for a healthier and more engaged political discourse. While social media platforms have allowed a distributed and unfettered source of information, fact checking by other platform providers or other media outlets might introduce their own biases and misinformation. However, if the source of information is easily interrogated, then at least a reader can assess the information based on the reliability of the original source. Technology can likely assist in this task.

Search engines have shown remarkable ability to scour the entire Internet to find relevant information based on queries. When someone posts information without identifying the source or without explaining the logic with which they developed the information, then the reader is conditioned to believe (or to reject) the posting based on faith and unsubstantiated belief. Research will lead to automated techniques to locate original sources or identify the combination of information and logic behind a piece of information. Automation of this sort will rely on cutting-edge artificial intelligence.

We recommend the following:

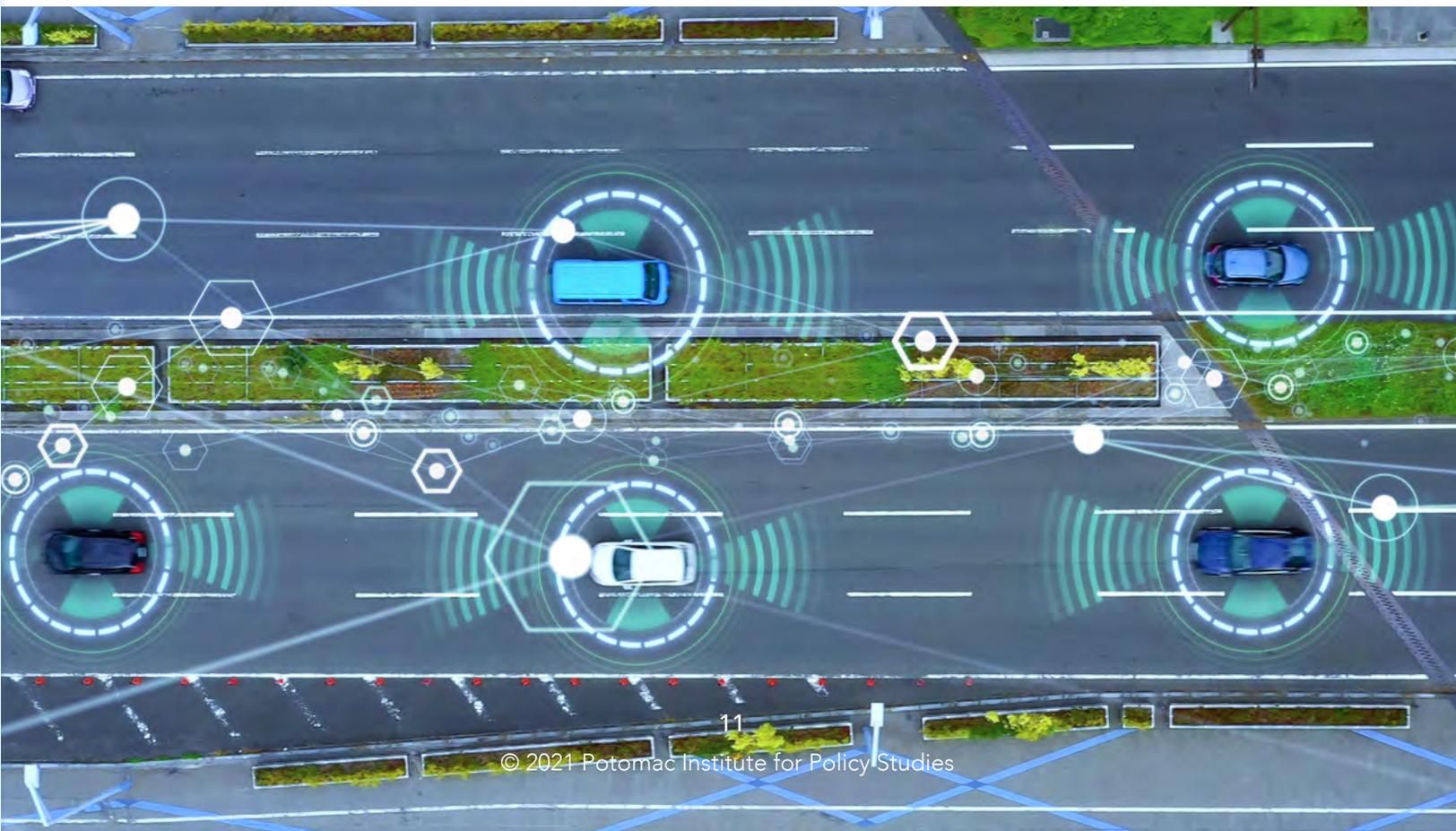
- Initiatives to develop techniques to automatically identify the provenance of information and the logic that was applied to develop published information. Promulgate these technologies within government so as to be able to analyze sources of information for intelligence and defense purposes, and to commercial media outlets so they can have better awareness of the international flow of ideas and can better label and authenticate information.
- Further, develop and promulgate techniques to automatically discriminate information from opinions from analysis, and develop standards and ways to make this capability readily available. Without thwarting analysis and opinions, assist intelligence analysts, military analysts, and the public consumers of media to distinguish primary information from derivative and interpreted information.

Advanced Transportation Technologies

The concept of smart roads and interconnected vehicles has long been promoted by departments of transportation and automobile associations. More recently, multiple efforts to assemble massive amounts of data gathered from transportation networks has shown great utility for optimizing traffic flow and for better understanding the mobility of people and logistics of goods. Self-driving vehicles and driving assistants are making great progress. Judicious design choices and secure use of such data could provide global benefits. America should foster S&T discoveries with new materials, new communication technologies, and new safety and security practices. Imagine the benefits when goods can be transported and delivered autonomously. Consider the possible benefits of eliminating traffic jams through efficient route planning. When interstate travel no longer requires the constant attention of a driver, productivity will increase, and society will benefit.

America should lead the way by:

- Accelerating the development of smart roads and smart transportation systems by setting standards, implementing pilot programs, and laying infrastructure to achieve smart cars and trucks for autonomous delivery of cargo and more efficient movement of people. Infrastructure renewal projects such as this should provide more than simple stimulus benefits.



Programmable Manufacturing

Advanced manufacturing technologies—sometimes referred to as digital and programmable manufacturing, which include robotics and automation—have received significant attention and funding for decades, spurred by government and industry investments. The recent focus on more reliable and robust supply chains and resilient adaptation of manufacturing, as well as the progression of technologies such as additive manufacturing, suggest new capabilities for which American investments could lead the way. Digital and programmable manufacturing processes, standards and new programming languages for manufacturing, and new generations of entrepreneurs could develop novel products by accessing such innovation facilities that could provide low-cost prototype production. Flexible manufacturing would make invocation of the Defense Production Act less intrusive, as retooling becomes far easier. But most importantly, domestic manufacturing might be reinvigorated, thereby reducing dependence on long supply chains vulnerable to natural or intentional disruptions.

Creating a more robust supply chain will require:

- Redoubling research into advanced programmable and flexible manufacture, using new materials and new manufacturing methods. Facilitating transition of technologies for manufacturing through standards for technologies such as additive manufacturing and advanced machining.
- Investing in pilot plants and new manufacturing facilities to reduce vulnerabilities to supply chain disruptions. Encouraging the development of new factories with flexible manufacturing capabilities and the use of novel materials. Using public-private partnerships to share manufacturing facilities to meet consumer as well as government needs.



Sustainable Materials and Recycling

Material science is on the cusp of a revolution. Carbon fiber, functionally graded materials, 3-D printing, and a host of other technologies offer the opportunity to produce lighter, stronger, and functionally novel materials. Today, our major industrial materials include asphalt, concrete, plastics, and bulk metals and alloys. Finding replacements and accelerating the development and use of improved materials for manufacturing and industrial use would greatly benefit society through new products and new capabilities. At the same time, decommissioning our existing products, recovering the valuable constituents, and cleaning waste to avoid spoiling the environment remain important challenges.

Technologies to improve recycling practices could automate the recovery of valuable resources, obviating labor-intensive preparation and separation. New technologies might be employed to “mine” our existing landfills to recover resources. Our massive use of plastic, reportedly 8 gigatons since the 1950s, has left us piles of refuse that are rarely recycled. Again, technologies could be developed that use bio-organic processes to break down and dissolve plastic waste, thereby reducing environmental impact. Similar technologies might lead to cleanup and remediation approaches, for example for oil spills in waterways or toxic sites from previous pollution events.

To improve sustainability, we recommend:

- Research into modern material science and facilitating the transition of new technologies to industrial manufacturing.
- Developing technologies to improve recycling and recovery of resources, to methods to reduce waste and remediate pollution, and facilitate transition of technologies to industrial waste management companies. Set goals for recovery of metals and develop improved and efficient separation techniques. Develop solutions for the disposal of plastics, to recover or reuse or decompose plastic refuse.





REBUILD THE INFRASTRUCTURE FOR AMERICAN EDUCATION

The U.S. has long been the go-to beacon of S&T in the world, cemented in the second World War, with the best universities and research laboratories, and with innovative industries that rapidly adapted and adopted new technologies. The U.S. leads the world in science Nobel prizes and remains the place for international students to come study science, and for scientists around the world to reach the pinnacle of their career in American institutions.

Continued American leadership in S&T is not guaranteed. Rivals to American dominance have learned the advantages of indigenous technological advances and have invested in long-range plans to attain excellence in S&T across broad ranges of disciplines. Science graduates in the U.S. have found opportunities elsewhere, and American enthusiasm for S&T has waned.

It is important to restore American leadership in S&T in order to attract the best scientists nationally and internationally, to provide for the best national security technologies, and to grow the economy with the best products and capabilities. Restoring American leadership in S&T is possible because of the talent and resources that exist. However, this requires a ready supply of scientists and technologists fed by a vibrant pipeline of training and engagement as well as protection of the intellectual property rights of the final product. The infrastructure for American S&T includes education, training, institutions, jobs, and laboratories. In the same way that American infrastructure of roads and bridges require attention, the infrastructure for the American S&T enterprise needs attention.

Adaptive Education at All Levels

Fundamentally, adaptive learning tailors an educational regimen to the individual, building from the fundamental principles set out in existing curricula. The national experiment with distance learning during the pandemic might result in new approaches to enable greater access to the most inspiring teachers. New approaches might include virtual reality or augmented reality to mimic in-classroom experiences, or even 3-D environments in local facilities to provide multi-student “caves.” The ability to reach new cohorts, by bringing the most inspiring teachers to remote locations through virtual communications, might inspire the next generation of scientific talent.

Cognitive psychology has long held promise to develop improved learning strategies, but greater data collection and improved testing might provide breakthroughs. There are better methods of student testing and progress measurement in comprehending STEM concepts, so there is an opportunity to develop new educational approaches based on data from short-term observations. Further, increased understanding from neuroscience, including approaches to conditioning, training, memory, and association might lead to improved education, especially in STEM areas. Heretofore, much of the neuroscience research has focused on disease and impairment; **opportunities exist to take information gathered from neuroscience for applications to other areas, such as learning and comprehension.**

Classroom learning has driven our education system for centuries. But it is well known that STEM fields require apprenticeships, laboratory experiences, personal discovery, and mentorships for effective development of new talent. With our recent mass endeavours in virtual learning, perhaps we can now develop better approaches to adaptive learning that reach all levels of training, where individuals receive more personalized attention. To accomplish this efficiently, research is needed on the ways that automated techniques, online learning, and efficient mentoring might provide talent training and placement. Of course, given that most scientific research is now conducted collaboratively means that development of social skills is equally important to STEM training.

Our recommendations concerning the education infrastructure for American S&T:

- Redouble STEM education programs and efforts at all levels of training. Emphasize access to knowledgeable training at younger grades, leveraging American university faculty and students to inspire grade school students through distance learning and outreach. Engage science researchers in government, academia, and industry to include educational outreach and mentorship of talented students throughout the nation.
- Use data-driven analysis to research and adopt improved education approaches. Support research into the understanding of approaches to learning, to understand what works best, and develop techniques for individualized training, especially emphasizing facilities for assimilation of new technologies and STEM concepts.

Communications for Collaborations

While it is not just S&T that benefits from new and growing communications technologies, the ability to communicate and collaborate across long distances has both enabled rapid S&T advancements and created opportunities to apply new S&T capabilities. The increased demand for “Internet of Things” devices, smart voice assistants, commercial artificial intelligence, and the like, are all based on rapidly expanding network capacities. As 5G telecommunications are still being rolled out, industry and government have begun envisioning possibilities for the next generation of communication capabilities, sometimes called 6G. China is exploring space-based terahertz communications for 6G.

America should lead the world in communications for our security and economy. Enhanced communications capabilities will provide major impetus to the American economy; it will also enable a revolution in our ability to connect, collaborate, and develop new capabilities based on advanced technologies. We certainly hope that returned normalcy includes face-to-face and group meetings, but the opportunities to use telecommunications provides efficiencies that are particularly pronounced for the American S&T enterprise.

Improving the education system will require cross-country, next generation communications as a foundation for information access. Without high-speed terahertz connections, distance learning will be a failed attempt at progress in education. Revitalizing education starts with putting the information at the fingertips of students of all ages and providing them the tools by which to learn. Social and collaborative interactions over long distances should feel as fluid as meeting together in person.

The nation needs to re-establish American leadership in communications technology for reasons of national security and economic stability, providing the technology, infrastructure, and tools to:

- Ensure that the U.S. leads in next-generation communications technology, also known as 6G communications, including wired, wireless, and satellite components. Work with American industries to accelerate adoption of standards, develop improved communication protocols across multiple media and communication types, providing appropriate backbone and local infrastructure components, and treating American industry as a critical industrial base element.
- Expand access to ensure that all Americans have affordable, high-speed, low latency access to broadband communications. Ensure that access includes not just devices with monitor screens, but also device-to-device communications, empowering the disadvantaged equal to those with greater means.

Rebuild the American S&T Institutions

Multiple U.S. agencies and entities support the American S&T enterprise by funding institutions. The National Science Foundation largely supports universities through research grants; the Department of Defense, the Intelligence Community, the military services, the Department of Homeland Security, and other agencies support institutions through sponsored research to universities, small businesses, industry, federally funded research and development centers, and non-profits. The many programs and initiatives have maintained a healthy American S&T environment. In all cases, the sponsoring entities need program managers and leaders who understand the science and can provide motivation and guidance to inspire performance of high-quality science and engineering.

The U.S. excels at education in the STEM fields. But we don't always do our best to retain the talent we spent decades training. The American S&T enterprise and the federal government need to incentivize ingenuity and retention. Redoubling education would emphasize K-12 grades through inspiring and talented teachers, but would also include higher education programs for science and engineering degrees. As important, practical S&T employment opportunities, throughout industry, academia, and government are necessary to create a "pull" for science education and to provide initial career landing zones. New visa policies are also required to bring in foreign talent and to increase stay-rates.

Thus, our recommendations for rebuilding the American S&T Institutions include the following:

- Engage strong, luminary, broad-based scientists in positions of leadership and management in agencies throughout the federal government. Develop new hiring authorities for government service in S&T, encourage sabbaticals and other temporary government service stints by scientists, and ensure that the best available science is infused into policy levels and decision processes in all branches of government.
- Demonstrate strong support for government, industry, and academic research in S&T through research projects and research partnerships that reinvigorate science and engineering institutions. Continue to refresh laboratories and facilities to ensure that American institutions are the envy of the world. Commission studies into American agencies of sponsored research to better understand what works and what needs reforms.

CAPITALIZE ON BIOTECHNOLOGY ADVANCES TO REMAKE HEALTH CARE

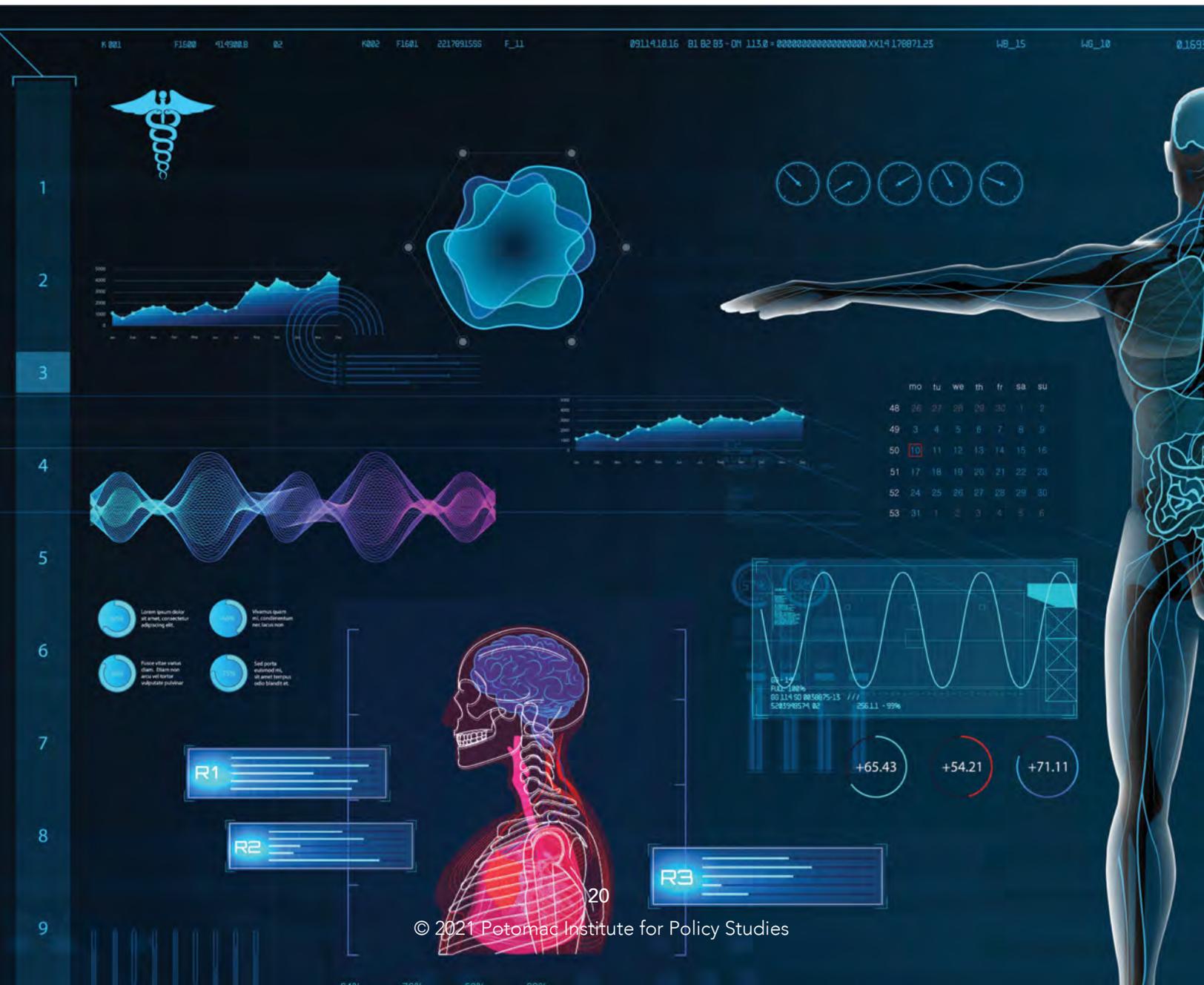
The biotechnology breakthroughs achieved in part due to advances used to fight the coronavirus pandemic should be leveraged for other major health benefits. While the pandemic has been tragic, it has spurred the international research community to accelerate the development of complex, highly scientific biotechnology, and has provided strong impetus for a transformation of health care delivery. Changing the ways we use technology will change the way we provide care for people.

Biotechnology research is conducted throughout multiple agencies in the U.S. government. However, to build on the momentum, new and bold research projects can be promoted. Rapid progress is expected and American leadership is required.



Biotechnology for Future Pandemics

To better prepare for risks associated with future pandemics, technologies can be pursued that provide broader spectrum therapies and vaccines, or faster ways to develop therapeutics and vaccines based on genetic sequencing and detailed knowledge of the threats. Biotechnologists should leverage the advances that were made with messenger RNA approaches to vaccine development. Further, improved international surveillance and secure tracking methods might prevent pandemics of the future. American leadership should extend the frontier of biology knowledge.



Accelerating Precision Medicine

Ever since the Human Genome Project, there has been great hope that data analytics and inexpensive sequencing could lead to the identification of the causes of genetic disorders and other diseases, and the development of therapies. Progress has been slow. With greater understanding of epigenomics and other “-omics,” opportunities expand. Enhanced data collection methods together with safe storage and access systems might permit a renewed emphasis on the use of data analytics to find correlations and intuit causes for diseases and health outcomes based on measurable data.

A revolution in health care is slowly developing due to massive collection of personal data, which includes collection by means of smart phones and wearables that can amass large volumes of detailed personal information. From individual movement, steps, and sleep data to heart function and oxygen level measurements, the data provides a wealth of opportunities to improve diagnostic medicine and preventative care. Again, there are procedural challenges, such as how to ensure access to personal information without compromising privacy. But, if these challenges can be solved, the massive increase in data due to wearables, personal monitoring devices, and digital healthcare databases will enable a revolutionary change in the analysis of baseline conditions and the detection of anomalies, which will lead to massive improvements in healthcare delivery and outcomes. Achieving better health outcomes while lowering overall costs can be achieved through machine learning and advanced analytics. Research in precision medicine will lead to a change in the healthcare system. Annual physicals will be replaced with automated alerts and preventative therapies. Challenges exist to secure access and ensure privacy to health data, but the potential benefits to health improvement are great.

Biotechnology is likely the new most exciting frontier of science and technology, with the potential for the greatest impact on our lives world-wide. Capitalizing on these advances, and securing American leadership, will require detailed plans, investments, and management, involving revitalized agencies and possibly new agencies, and coordinated responses. Our recommended goals include:

- [Maintain momentum on rapid vaccine and therapeutics development, addressing other major illnesses.](#)
- [Fund international biotech endeavors at a level that positions America as a global leader.](#)
- [Accelerate the transformation of U.S. healthcare delivery to enable precision medicine and biotechnology-based wellness and health delivery services.](#)
- [Leverage biotechnology advances to promote greater trust in S&T, more broadly.](#)

LEVERAGE S&T TO REDUCE THE GREATEST RISKS CONFRONTING SOCIETY

Science and technology have led the progress in military affairs and security, and in development of products that benefit humankind. Military technology developments have also led to increased lethality and have been used in warfare as well as for deterrence. At this point in time, the nation faces severe threats, both natural and man-made. Many are enumerated in the Intelligence Community's Worldwide Threat Assessment from 2019, and a new such assessment needs to be performed, updating probabilities of occurrences. Some threats include:

- Global climate change due to anthropogenic activities and natural influences.
- New pandemics and natural bio threats.
- Resurgent peer competitors, especially Russia and China, with renewed offensive military capabilities and threats to supply chains.
- Weapons of Mass Destruction (WMDs), also known as CBRNE threats (chemical, biological, radiological, nuclear, and explosives).
- Threats of nature: Earthquakes, volcanoes, tsunamis, hurricanes, asteroids, etc.
- Influence operations by malevolent actors to disrupt society.

Each of these threats, among others, present daunting challenges. But we can still have faith that the American intellect can confront, mitigate, and/or deal with these serious threats. Once again, it is S&T in conjunction with policies, diplomacy, and good practices that can address threats. Mitigating these threats includes defending all of humanity.

Because resources are limited, we need wise resource allocation, based on a sensible prioritization and risk analysis. Scientists need to develop technological solutions wherever possible, balancing short-term and long-term objectives with levels of acceptable risk. Leveraging international collaborations is worthwhile but needs to be handled carefully to avoid assisting adversaries against our interests. Management of the options is as hard as the development

of ideas to explore. But the opportunity is to utilize our demonstrated excellence in S&T to develop defenses against the most likely threats. The key is to both develop technological solutions whenever possible, and to balance long-term with short-term approaches.

The implementation begins with a realistic assessment of the threats confronting the nation, which should be conducted rationally from a fresh baseline. We are accustomed to thinking in terms of kinetic weapons and long-range missiles, but non-kinetic threats must now be considered equally seriously. Threats include dynamic, adaptive adversaries that might engage in economic warfare, perform information operations to influence populations to act against their best interests, or disrupt supply chains to promote their own interests. Strategic investing to maximize threat reduction must account for a measure of the consequence of the threat as well as the likelihood of achieving a solution. Leaders who understand the S&T are necessary ingredients.

Some of the relevant technologies that can address these threats are new and emerging disciplines, such as cognitive security and artificial intelligence applied to massive data collections. Other technologies are familiar, such as clean energy, biotechnologies, and detection and surveillance sensor systems. Much of the research falls into the realm of intelligence, as opposed to offensive military system development. Accordingly, new approaches to intelligence gathering and analysis are required. A good defense includes both a good understanding of the offensive capabilities and an ability to deter an adversary. Thus, maintaining a leadership role in these technologies is important to national security and ultimately to all forms of threat reduction.

Certain ongoing efforts should be organized as large and prominent research projects, to muster broad participation. Other national initiatives should be established to confront threats. We suggest here four large-scale agendas: clean energy, mitigation of global climate change, data analytics for intelligence analysis, and cognitive security.

“We live in a society exquisitely dependent on science and technology, in which hardly anyone knows anything about science and technology.”

– Carl Sagan

Clean Energy

While the Earth is awash in energy resources, uneven distribution and the consequences of non-renewable energy production lead to conflicts and threats to societies throughout the world. Many distinct efforts exist across many different U.S. organizations for exploring, developing, and fielding new energy production and energy distribution systems. Many are aimed at reducing greenhouse gas emissions. But the overall goal is to reduce the cost of providing energy resources to humanity, to distribute those resources as evenly as possible, and to not degrade the environment and the livability of the Earth. The underlying science is often cutting-edge and complex. Bold ideas for energy harvesting, for example from space, would transform society. Not relying on distribution of energy as a utility would enable a new way of life in America.

Ultimately, we need to explore and adopt non-fossil fuel options for the future. Our recommendations include:

- Muster the resources to ensure American leadership in clean energy.
- Coordinate across agencies, engaging universities, federally-funded R&D institutions, industry, and non-profits to lead the charge to a sustainable, abundant, affordable energy future. Pursue multiple paths, from more efficient generation and distribution of energy, to local production and storage, considering solar generation, nuclear fission, and harvesting resources in space. Pursue both high risk and established technologies, such as superconducting electric distribution and wind-powered turbines built in American factories utilizing novel structural materials.

“The greatest enemy of knowledge is not ignorance, it is the illusion of knowledge.”

– Stephen Hawking



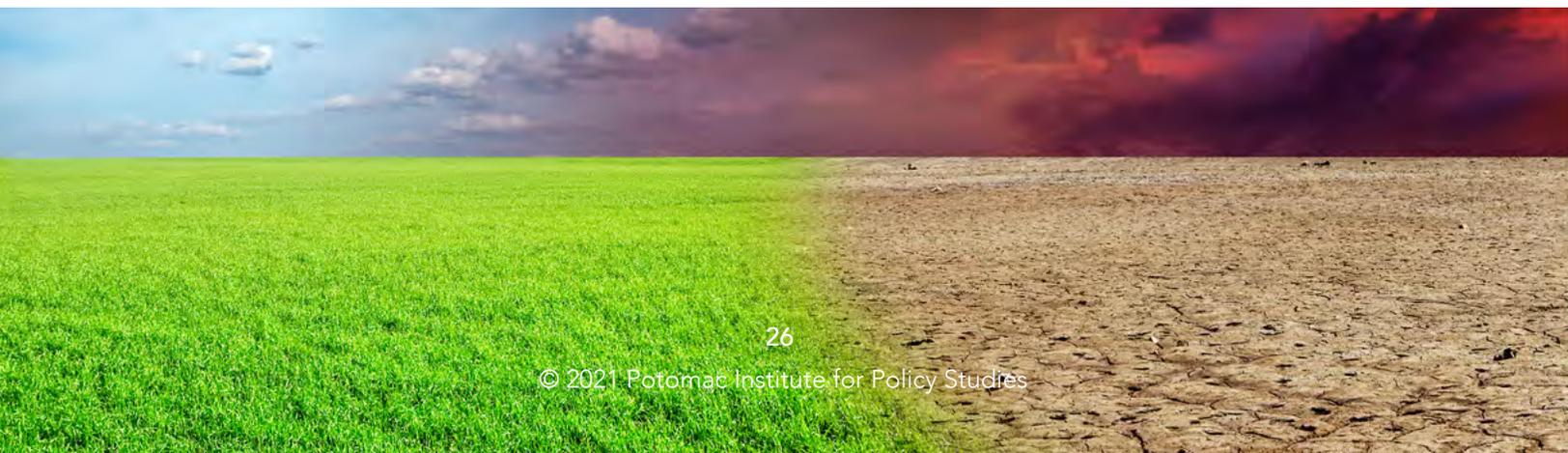
Mitigate Global Climate Change

Eliminating the use of wood, coal, and other fossil fuels for energy production worldwide will massively reduce greenhouse gas emissions, and thus reduce our deleterious effects on the global climate. However, this transformation will not mitigate the current state of the planet. The US has the opportunity to **build back better** through climate engineering, carbon sequestration, using new tools and technologies to harvest greenhouse gases for beneficial use, cleaning up our atmosphere to restore a reasonable energy balance.

Science and technology can offer assistance, if not solutions, that might mitigate the negative effects on the planet. However, the task is large, and challenges exist in many areas. Broad scientific expertise will be needed. Reducing the emission of greenhouse gases from production other than for energy—such as leaks of methane, flaring of natural gas, disposal of decomposables that emit carbon dioxide, farming emissions, and incineration of plastics—needs to be addressed to reduce their contributions to climate change. Technologies that provide cleaner substitutes and/or practices that reduce emissions are needed. Bolder approaches have been suggested, and research is warranted. For example, methods for sequestering carbon dioxide have been explored, and methods to reform carbon dioxide or remove it from the atmosphere by means other than plant photosynthesis hold promise. Geoengineering of the planet to reduce energy absorption has been studied academically; it is time to translate that research to technology development. This investment will support a large influx of engineers in the US to create a sustainable future.

Our recommendations to mitigate global climate change include:

- Support intensive research efforts to provide approaches to mitigate and confront the effects of global climate change.
- Pursue approaches that not only reduce the emission of greenhouse gases into the atmosphere and environment but include in the research methods that might transform methane and carbon dioxide to be less impactful to global climate and investigate long-term approaches to establishing a restored energy balance to the planet.

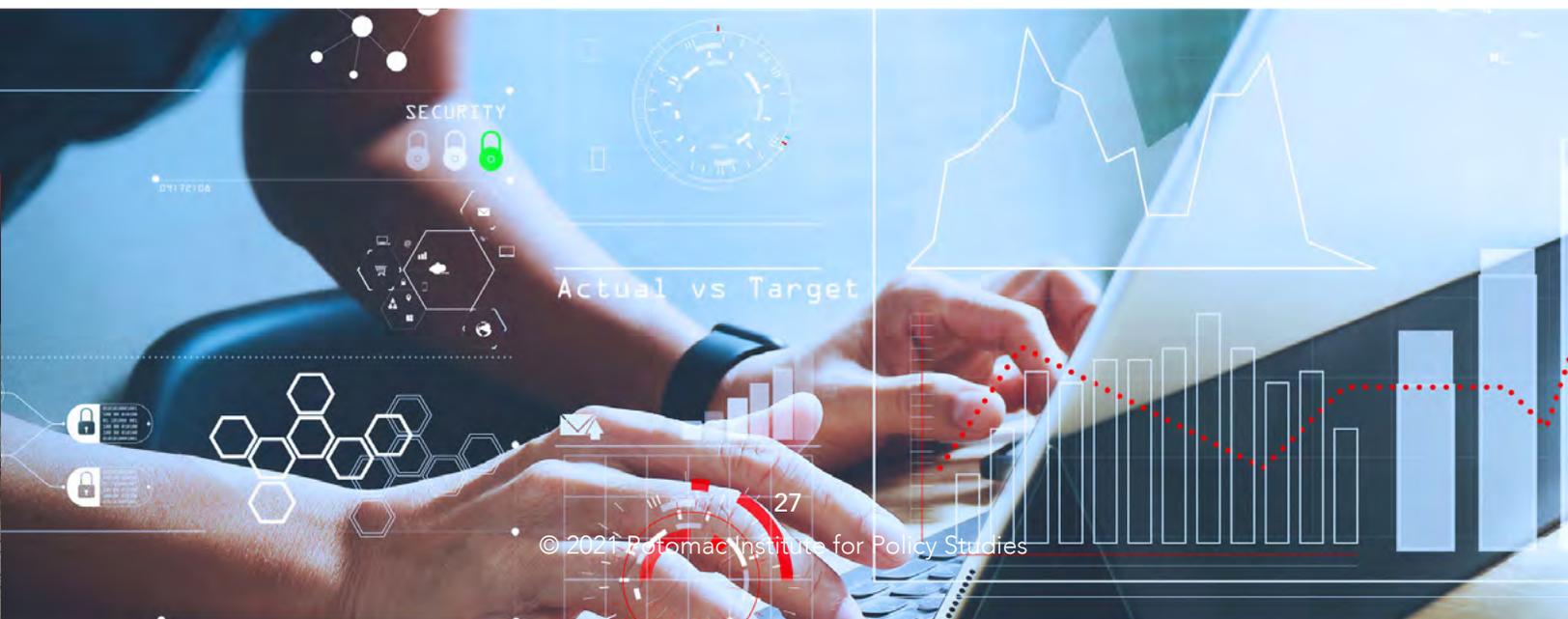


Data Analytics for Intelligence Analysis

Addressing many of the adversarial threats that challenge the United States requires new intelligence gathering, which in turn requires new approaches to data analysis. The recent surge in the field of artificial intelligence is based on the use of massive data training sets to discover patterns for the purpose of classifying observed information. The true revolution is the availability of massive amounts of digital data that documents just about every activity of every human on Earth, coupled with the processor power that can ingest and analyze that data. Data analytics, which can be thought of more broadly than artificial intelligence (AI), offers the opportunity to transform intelligence gathering and threat awareness. Broadening the mission of the national AI initiatives and integrating research efforts in the full range of data analytics could lead to prototype applications that predict threats and provide prescriptive approaches to mitigation. However, research is needed to determine which applications are amenable to automated data analytics, and how to affordably obtain training data that is representative of the problem. Methods to detect anomalies in data sets that indicate deviation from normalcy, and thus might require human analysis, are also on the forefront of data science.

We recommend:

- Transform intelligence gathering and threat awareness through the informed use of data analytics.
- Organize S&T research in the intelligence community and in support of military intelligence in ways that make maximum use of novel and emerging sources of information, considering global coverage by new commercial assets and opportunistic sources, and while respecting the freedoms that persons should share everywhere, develop the technologies to accurately detect threats to persons and populations.



Cognitive Security

Adversaries have recognized that cyber hacking and influence operations can attack American interests without involving kinetic means. Our responses have not, so far, caused these attacks to cease. While we have invested heavily in cyber security and cyber defenses—not entirely successfully—the challenge of defending against disinformation campaigns and manipulation of beliefs is in its infancy, despite the critical risk. The burgeoning field of cognitive security is about understanding the threat posed by malicious dissemination of misinformation and defending our right to form our own beliefs without undue influence. Moreover, influence operations are involved in the recruitment of people by destructive or violent organizations.

To rebuild trust in America, we need to discriminate intentions in an information-rich society, and to defend individual and societal cognitive freedom. We previously noted that much research is ongoing concerning authentication of sources and validation of information. Other research examines cognitive biases and pre-conditioning of emotions and influences. National security dictates that we find solutions to defend ourselves against external influence campaigns so that we can maintain a free and open society.

To defend against disinformation, we recommend:

- Research to employ methods to detect, deter, and counter disinformation campaigns and influence operations to maintain cognitive security of the population.
- Establish rigorous sociological analysis to understand the effects and influences of untoward recruitment and manipulation, with increased development of the fields of neuropsychology, cognitive psychology, neuroscience of emotions, addictions, and memory.



SUMMARY

The U.S. is 4.25% of the world's population, a quarter of the world's economy, and the leader in S&T. Leading in S&T is the ultimate offset strategy, giving rise to security and prosperity out of proportion to the population size. Yet, that lead is not guaranteed, and must be sustained through focused policies and initiatives. Today, the U.S. leadership position in S&T is in jeopardy in a variety of disciplines. The new administration has the opportunity to shore up American leadership in S&T through implementation of the ideas outlined in this document.

There are steps that can improve respect for American S&T, both in the U.S. and internationally—appreciation and respect for American S&T is necessary for upholding societal support and persistence of excellence. In concert with ensuring a ready supply of scientists and technologists for American leadership in S&T, the infrastructure for education, training, institutions, jobs, and laboratories needs attention. The reality of the COVID-19 pandemic has emphasized the importance of advances in biotechnology, and the momentum thus gained offers some important new opportunities. And finally, we believe that renewed emphasis on cutting-edge science and technology can confront the greatest threats to the nation and the world, such as global climate change, natural and man-made threats, and influence operations.

Science and technology have been America's ace card in the past. Going forward, restored respect for S&T and new policies and initiatives to leverage our S&T advantages will be a lasting legacy for which the administration will be justly proud.



$$P(x_1, x_2) = \frac{\binom{A}{k} \binom{B}{n-k}}{\binom{A+B}{n}}$$

$$P(x) = \frac{x^{\alpha-1} e^{-x/\beta}}{\beta^{\alpha} \Gamma(\alpha)} \text{ if } 0 \leq y \leq \infty$$

$\Sigma(B+G) x$ innovat

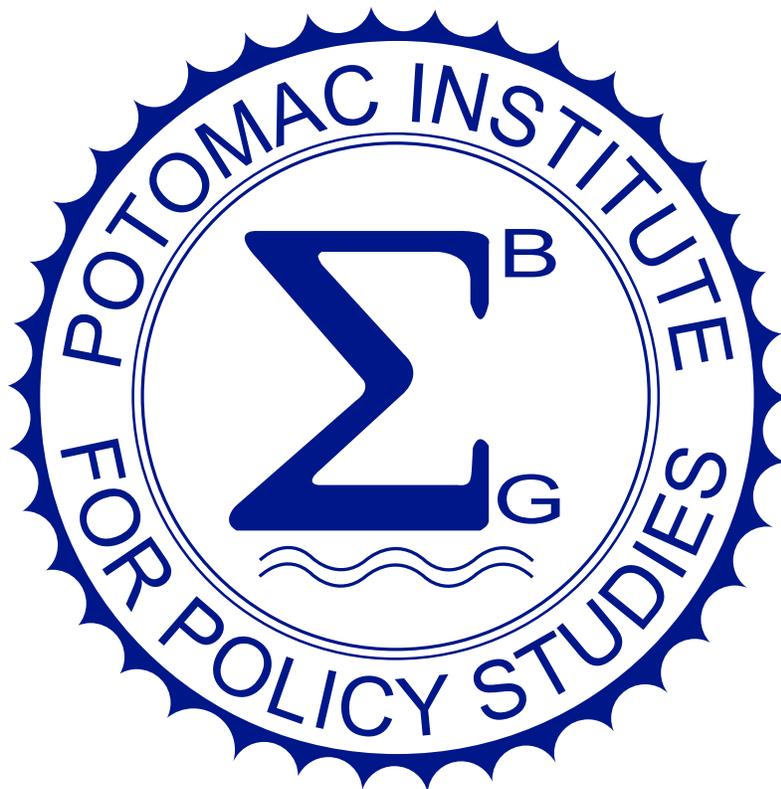
$$\lambda x e^{-\lambda}$$

$$\sum_{i=1}^n (x_i)$$



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The Potomac Institute for Policy Studies is an independent, 501(c)(3), not-for-profit public policy research institute. The Institute identifies and aggressively shepherds discussion on key science, technology, and national security issues facing our society. The Institute hosts academic centers to study related policy issues through research, discussions, and forums. From these discussions and forums, we develop meaningful policy options and ensure their implementation at the intersection of business and government. The Institute remains fiercely objective, owning no special allegiance to any single political party or private concern. With over nearly two decades of work on science and technology policy issues, the Potomac Institute has remained a leader in providing meaningful policy options for science and technology, national security, defense initiatives, and S&T forecasting.



*“Everything is
theoretically
impossible
until it’s done.”*

– Robert A. Heinlein

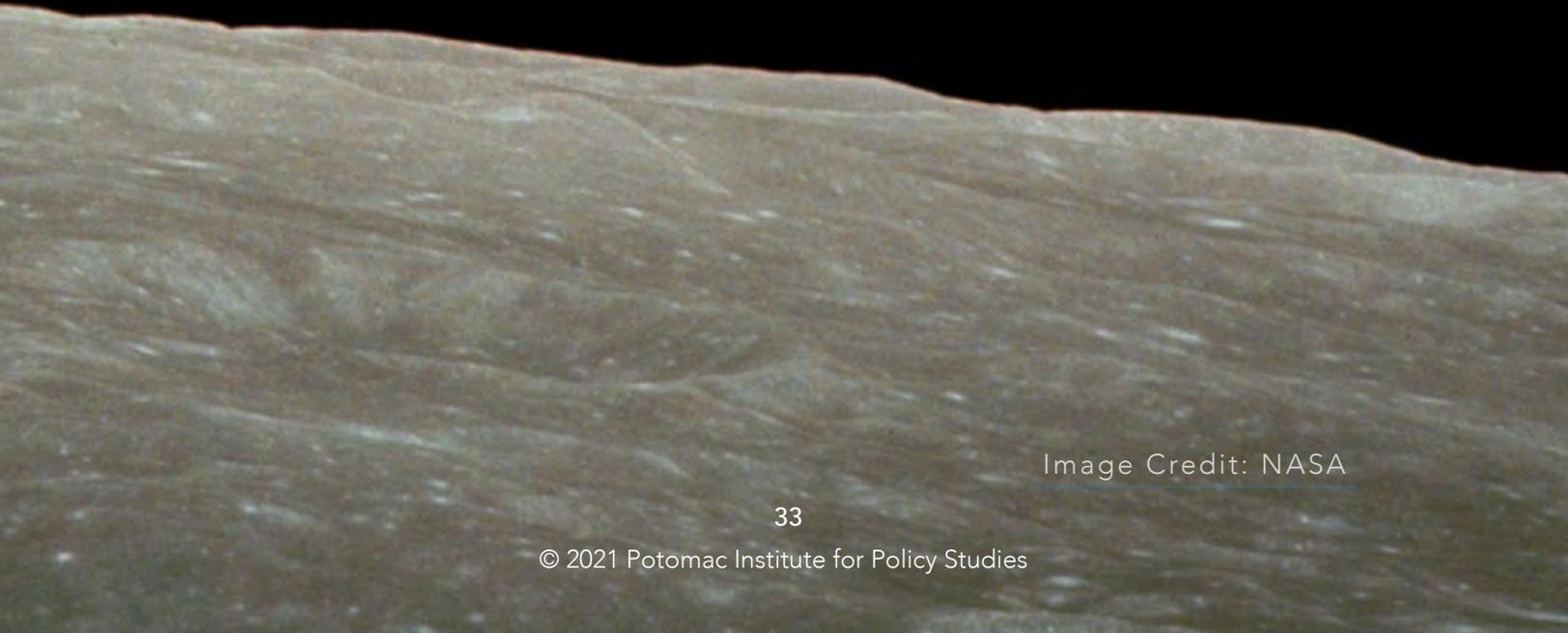


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*“Science is the key to our future,
and if you don’t believe in science,
then you are holding everybody back.”*

– Bill Nye

