Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Defense Advanced Research Projects Agency	Date: May 2021
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602715E / *MATERIALS AND BIOLOGICAL TECHNOLOGY*

COST ($ in Millions)	Prior Years	FY 2020	FY 2021	FY 2022 Base	FY 2022 OCO	FY 2022 Total	FY 2023	FY 2024	FY 2025	FY 2026	Cost To Complete	Total Cost
Total Program Element	-	260.831	245.107	317.024	-	317.024	-	-	-	-	-	-
MBT-01: *MATERIALS PROCESSING TECHNOLOGY*	-	111.417	98.041	137.326	-	137.326	-	-	-	-	-	-
MBT-02: *BIOLOGICALLY BASED MATERIALS AND DEVICES*	-	149.414	147.066	179.698	-	179.698	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

The Materials and Biological Technology Program Element is budgeted in the Applied Research Budget Activity because its objective is to develop materials and biological technologies that make possible a wide range of new military capabilities. This Program Element also supports innovation and robust transition planning in the technology cycle by working with entrepreneurs to increase the likelihood that DARPA funded technologies take root in the U.S. and provide new capabilities for national defense.

The major goal of the Materials Processing Technology project is to develop novel materials, fabrication and processing techniques, models, devices and components that will lower the cost, increase the performance, and/or enable new missions for military platforms and systems. Included in this project are efforts across a wide range of technology areas including manufacturing, electronics, sensors, optics, and complex and autonomous systems.

The Biologically Based Materials and Devices project will leverage the growing application space of the biological sciences for the development of new DoD capabilities in materials development, threat detection, and warfighter performance. Contained in this project are thrusts that apply biology's unique synthesis capabilities to source DoD-relevant materials and overcome current limitations in accessing, scaling, and distributing critical resources to achieve overmatch. Programs in this project also enable in situ and stand-off detection and mitigation of biological, chemical, traditional, and emerging threats against the warfighter, the food supply, and other targets. This project also includes efforts to develop novel biological technologies for maintaining human combat performance.

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B. Program Change Summary ($ in Millions)	FY 2020	FY 2021	FY 2022 Base	FY 2022 OCO	FY 2022 Total
Previous President's Budget	214.976	250.107	245.748	-	245.748
Current President's Budget	260.831	245.107	317.024	-	317.024
Total Adjustments	45.855	-5.000	71.276	-	71.276
• Congressional General Reductions	0.000	-5.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	53.077	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	-0.923	0.000			
• SBIR/STTR Transfer	-6.299	0.000			
• TotalOtherAdjustments	-	-	71.276	-	71.276

Change Summary Explanation

FY 2020: Increase reflects COVID response CARES Act add offset by reprogrammings and SBIR/STTR transfer.

FY 2021: Decrease reflects congressional adjustments.

FY 2022: Increase reflects initiation of the Bio-Inspired Coastal Defense program in the Biologically Based Materials and Devices project, as well as, transition from design and initial development to prototype development and testing in the Functional Materials and Devices thrust in the Materials Processing and Technology project.

Exhibit R-2A, RDT&E Project Justification: PB 2022 Defense Advanced Research Projects Agency			Date: May 2021
Appropriation/Budget Activity 0400 / 2	R-1 Program Element (Number/Name) PE 0602715E / *MATERIALS AND BIOLOGICAL TECHNOLOGY*	Project (Number/Name) MBT-01 / *MATERIALS PROCESSING TECHNOLOGY*	

COST ($ in Millions)	Prior Years	FY 2020	FY 2021	FY 2022 Base	FY 2022 OCO	FY 2022 Total	FY 2023	FY 2024	FY 2025	FY 2026	Cost To Complete	Total Cost
MBT-01: *MATERIALS PROCESSING TECHNOLOGY*	-	111.417	98.041	137.326	-	137.326	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

The major goal of the Materials Processing Technology project is to develop novel materials, fabrication and processing techniques, models, devices and components that will lower the cost, increase the performance, and/or enable new missions for military platforms and systems. Included in this project are efforts across a wide range of technology areas including manufacturing, electronics, sensors, optics, and complex and autonomous systems. This Project includes FY 2020 CARES Act funding in the amount of $29.077 million to develop U.S. sourced production capabilities for chemical precursors needed to produce pharmaceuticals critical to SARS-CoV-2/ COVID-19, and assess the efficacy of Food and Drug Administration (FDA)-approved therapeutic drug candidates for treatment of COVID-19 patients.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Materials for Extreme Environments	20.006	42.041	56.094

Description: The Materials for Extreme Environments thrust is exploring new materials, innovative architectures, and development processes that will significantly enhance the performance and persistence of DoD platforms operating in extremely harsh environments. Materials with superior strength, functionality, and resiliency are critical for enabling DoD platforms, weapons and other components to operate and persist under conditions including, but not limited to, extremely high or low temperatures, turbulence, ionizing radiation, and/or corrosive environments. Recent developments in materials such as high entropy alloys, infiltrated carbon fiber composites, and synergistic processing hold promise for achieving material solutions for improved survivability in a wide range of harsh environment conditions. Similarly, advancements in material design, processing and manufacturing are enabling novel material architectures that can further enhance performance and resilience in structures such as leading edges, windows and apertures, propulsion systems, and space structures. Exemplar areas of research within the Materials for Extreme Environments thrust include the following: 1) high temperature materials for hypersonic platforms; 2) high temperature window and aperture materials; 3) radiation and/or electromagnetic pulse (EMP) hardened electronics for space platforms; and 4) coatings for platform survivability in corrosive environments.

FY 2021 Plans:

- Investigate mechanical/physical/chemical properties of high entropy alloys for applications in extreme environments.
- Conduct arc-jet testing on architected material coupons to quantify material performance.
- Identify and integrate advanced diagnostic capabilities into relevant test facilities to monitor material response in real time.
- Demonstrate scalable manufacturing processes to enable multifunctional structural/thermal leading edge structures for hypersonic vehicles, including scaled leading edge coupons with microscale features for heat pipe, transpiration and phase-change functionality.

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
- Identify material approaches to enable operational Infrared/Radio Frequency (IR/RF) performance at temperatures characteristic of hypersonic flight. - Develop models to predict operational impact of improved radome materials. - Identify materials that are amenable to manufacture in the space environment. - Identify technologies such as robotic self-assembly and low power curing that can be modified for zero gravity operation. ***FY 2022 Plans:*** - Validate component level models for scaled cooled leading edge structures under high aerothermal conditions. - Conduct integration studies for scaled cooled leading edge components to facilitate technology transition. - Manufacture scaled architected leading edge structures with integrated cooling and demonstrate under high heat flux conditions. - Develop new test capabilities for testing IR/RF performance under high temperature oxidative conditions. - Demonstrate novel sensing capabilities suitable for hypersonic platforms under high temperature conditions. - Identify new designs and stabilization techniques for ultra-low mass density structures suitable for on-orbit applications such as solar arrays, antennas and optical surfaces. - Laboratory demonstration of critical materials manufacturing steps to enable ultra-low mass density structures. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** The FY 2022 increase is due to the shift from initial design to development and testing.			
Title: Functional Materials and Devices	11.060	20.500	46.204
Description: The Functional Materials and Devices thrust is developing advanced materials, components and systems to improve device performance for DoD sensing, imaging and communication applications. One focus of this thrust involves development of advanced transductional materials that convert one form of energy to another for DoD-relevant applications in areas such as thermoelectrics. While promising transduction materials are known for a variety of applications, integration into devices has not been realized. Another focus area is the development of physics based models that predict material behavior when illuminated by high peak power electromagnetic interference. A third focus area involves development of new multi-functional materials and device designs that will radically decrease the size, weight and power requirements of neutron and gamma sources for high-resolution neutron, gamma and x-ray imaging. Such devices should enable fieldable detection units for non-destructive evaluation of parts, detection of explosives and other DoD-relevant targets. ***FY 2021 Plans:*** - Refine compact gamma ray source component technology designs and plan for integration of component technologies into compact, mono-energetic gamma ray source prototypes. - Mature component and system modeling efforts to support realization of prototype test beds for intense, compact, mono-energetic gamma ray sources.			

Exhibit R-2A, RDT&E Project Justification: PB 2022 Defense Advanced Research Projects Agency		Date: May 2021
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
- Explore novel algorithms and sensors for passive 3D night vision. - Create a preliminary ground-truth database of the ambient infrared light present in off-road environments. - Develop understanding of the fundamental trade-space between night vision system field of view, bandwidth, efficiency, and overall system length/weight using planar optics and novel materials for transduction. - Develop fundamental understanding of photon upconversion bandwidth and efficiency; identifying methods of achieving high-efficiency upconversion across the infrared to the visible. - Define system requirements for a compact ruggedized linear accelerator. ***FY 2022 Plans:*** - Complete initial prototype test beds for compact gamma ray sources that feature high intensity, tunability, and narrow bandwidth. - Conduct initial demonstrations of prototype test beds for compact gamma ray sources that are capable of meeting base phase performance goals for intensity and bandwidth. - Design novel techniques to extract 3-dimensional information from infrared data. - Perform spectral analysis of passive thermal emissions to mathematically determine object structures. - Perform co-optimization of planar optics and materials for transduction to identify paths towards low torque (less than 0.2 nanometers) night vision systems providing visual access to at least 1,550 nanometers with a greater-than 60 degree field-of-view. - Develop and verify a system design for a compact ruggedized linear accelerator system. - Complete testing of critical compact ruggedized linear accelerator components to validate they can provide the required performance. - Investigate limits of microscale architecture for achieving high performance active acoustic materials such as piezoelectric, magnetostrictive and multiferroic materials for deep water operation. - Explore opportunities for adapting advances in energy harvesting and recovery for applications in austere locations. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** The FY 2022 increase is due to the transition from initial component design to integrated system design.			
Title: Chemical Processing for Force Protection	37.684	13.000	19.028
Description: Research in the Chemical Processing for Force Protection thrust is focused on the development of new chemical approaches and technologies across a broad spectrum of DoD needs. One area involves development of innovative approaches for scalable small molecule synthesis coupled with predictive tools for route design, possibly offering a new strategy to discover how to make new molecules such as pharmaceuticals and explosives. Another focus leverages advances in automation to develop safe, reproducible experimental approaches for systematic development of energetic materials. In addition, investments in this thrust will advance chemical characterization, information management and analysis, and automation.			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
FY 2021 Plans: - Develop standardized protocols for conducting energetic-relevant experimentation using minimal quantities of energetic compounds. - Design and begin constructing semi-automated experimental capabilities that integrate energetic ingredient synthesis with formulation development and testing to enable a safer, more rapid, systematized design of experiments approach to energetics development. - Leverage new energetic synthesis pathways to initiate development of advanced energetic formulations for one or more DoD-relevant applications. ***FY 2022 Plans:*** - Demonstrate semi-automated, reproducible experimental systems that integrate more than three explosive ingredients at scales over 10 grams per formulation with on-board sensitivity tests. - Extend semi-automated experimental systems to handle materials for propellant development, with automated integration of more than six propellant ingredients at scales over 25 grams per formulation. - Demonstrate accurate and safe determination of explosive and propellant metrics using gram-scale quantities. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** The FY 2022 increase is due to the transition from initial design to system development and demonstration.			
Title: Multi-Scale Modeling	16.000	15.000	9.000
Description: The Multi-Scale Modeling thrust is developing advanced, multi-physics models that can predict the effect of disturbances and/or perturbations in the space environment in order to inform operational decisions based on current space environment conditions. Current space environment models are limited to predicting long term climatic averages or regularly occurring phenomena and do not fully account for coupling effects where perturbations in one region of the space environment may produce disturbances in another region. Approaches for addressing these limitations under the Multi-Scale Modeling thrust include the following: (1) development of observation driven/first-principles theory of magnetosphere-ionosphere-thermosphere coupling; (2) creation of an extensible assimilation framework for unifying space environment monitoring systems and data; and (3) non-traditional space environment measurement approaches. These developments will ensure the accuracy and spatiotemporal resolution of space weather models and is sufficient to enable prediction of operationally relevant perturbations and disturbances in the space environment. ***FY 2021 Plans:*** - Demonstrate in simulation the ability to predict and track phenomenon with scale lengths as small as one hundred kilometers. - Demonstrate the extensible data assimilation frameworks ability to process all data sources in less than fifteen minutes with a minimum of two major observation networks integrated and one synthetic source of data.			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
- Demonstrate the capability of plasma physics models to simulate wave/particle interactions necessary to inform understanding of electron depletion by electromagnetic (EM) waves. ***FY 2022 Plans:*** - Demonstrate and field test an integrated space environment forecasting capability to predict perturbation and disturbances within scale lengths as small as one hundred kilometers, every hour, within a seventy-two-hour window, and over an area representative of an operation area of responsibility. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** The FY 2022 decrease is due to the transition from heavy system development to demonstration.			
Title: Reconfigurable Systems ***Description:*** In the Reconfigurable Systems thrust, new approaches are being developed to enable more rapid and robust adaptation of defense systems and systems-of-systems to changing mission requirements and unpredictable environments. This includes development of capabilities across sensing, perception, planning and control for autonomous, high-speed operation in cluttered environments without Global Positioning System (GPS) information. This also includes development of capabilities to manipulate and control adversary sensory perception and/or situational awareness. Additional work in this thrust focuses on how sensing systems and military systems-of-systems are designed for real-time resilient response to dynamic, unexpected signals and contingencies. Research is developing a more unified view of system behavior that allows better understanding and exploitation of complex interactions among components, including development of formal mathematical approaches to complex adaptive system composition and design. These capabilities will impact autonomous systems and systems-of-systems, including those that involve humans, in a variety of DoD-relevant contexts. ***FY 2021 Plans:*** - Explore designs for a portable optical clock physics package capable of demonstrating stability of fifty femtoseconds at one second maintained over a day. ***FY 2022 Plans:*** - Initiate efforts to demonstrate sub-picosecond optical time transfer over a range of greater than fifty kilometers. - Finalize design for a portable optical clock with a frequency comb capable of demonstrating precise (picosecond) two-way optical time transfer. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** The FY 2022 increase is due to the transition from initial component demonstration to integrated system demonstration.	9.650	3.000	7.000
Title: Accelerating Discovery and Innovation	15.017	4.500	-

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Description: The Accelerating Discovery and Innovation thrust is developing new approaches, tools and technologies to speed the pace of scientific discoveries and technological innovations from idea generation and fundamental research through integration of technologies into fieldable products and systems in production. The path from idea generation to a discovery is a lengthy, complex process involving many unpredictable steps, cycles and stages across fundamental and applied research and development. Research in this thrust is focused on developing and implementing strategies to address many of the challenges and bottlenecks inherent along this path and to speed the rate at which an idea can be advanced into a concrete capability. Specific approaches include advanced multiplayer gaming technologies to catalyze development of new technology concepts, development of tools for data collection and visualization to accelerate fundamental and applied research, and strategies to understand how seemingly benign commercially available technologies may be converted or combined into threats to military operations, equipment or personnel. ***FY 2021 Plans:*** - Apply and evaluate online, multi-platform structured conversation tools for rapidly identifying evidence-based development opportunities. - Employ and evaluate online conversation tools to expedite the identification and vetting of research ideas. - Evaluate the success of research projects developed via online structured conversation tools. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** The FY 2022 decrease is due to program completion.			
Title: Materials Processing and Manufacturing ***Description:*** The Materials Processing and Manufacturing thrust explored new manufacturing and processing approaches that dramatically lowered the cost and decreased the time required to fabricate DoD parts and systems. Constantly changing specifications for DoD platforms combined with recent manufacturing advances, such as 3D printing and manufacture on demand, drive a need for greater efficiency in development and design cycles as well as scalable and reconfigurable manufacturing processes that incorporate advanced materials with superior properties. Research within the Materials Processing and Manufacturing thrust focused on achieving the following capability objectives: (1) scalable processes to assemble fully 3D devices that include nanometer- to micron-scale components; (2) processes that yield new materials, materials capabilities and parts that cannot be made through conventional processing approaches; (3) efficient, low volume manufacturing; (4) approaches that reduce manufacturing complexity through new material feedstock formats with reconfigurable processing techniques; and (5) material processing that enhances platform survivability in extreme environments.	2.000	-	-
Accomplishments/Planned Programs Subtotals	111.417	98.041	137.326

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C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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COST ($ in Millions)	Prior Years	FY 2020	FY 2021	FY 2022 Base	FY 2022 OCO	FY 2022 Total	FY 2023	FY 2024	FY 2025	FY 2026	Cost To Complete	Total Cost
MBT-02: *BIOLOGICALLY BASED MATERIALS AND DEVICES*	-	149.414	147.066	179.698	-	179.698	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

The Biologically Based Materials and Devices project will leverage the growing application space of the biological sciences for the development of new DoD capabilities in materials development, threat detection, and warfighter performance. Contained in this project are thrusts that apply biology's unique synthesis capabilities to source DoD-relevant materials and overcome current limitations in accessing, scaling, and distributing critical resources to achieve overmatch. Programs in this project also enable in situ and stand-off detection and mitigation of biological, chemical, traditional, and emerging threats against the warfighter, the food supply, and other targets. This Project also includes efforts to develop novel biological technologies for maintaining human combat performance. This Project also supports innovation and robust transition planning in the technology cycle by working with entrepreneurs to increase the likelihood that DARPA funded technologies take root in the U.S. and provide new capabilities for national defense. This Project includes FY 2020 CARES Act funding in the amount of $24.0 million to test ultra-sensitive methods for diagnosing COVID-19, discover completely novel clustered regularly interspaced short palindromic repeats (CRISPR)-based therapies against COVID-19, and assess the efficacy of Food and Drug Administration (FDA)-approved therapeutic drug candidates for treatment of COVID-19.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Persistent Terrestrial Living Sensors	15.790	15.832	18.672
Description: The Persistent Terrestrial Living Sensors program is developing engineered biological sensor platforms capable of detecting land-based threats (e.g., chemicals, radiation, explosives, biologics) and relaying unique signals to existing DoD ground, air, and space assets. Unlike conventional methods that monitor threats and are limited by sensor energy needs, these biological sensors are effectively energy independent, increasing the potential for wide distribution and environmental robustness. Resulting platforms developed within this program will enable a variety of remote, persistent monitoring and reporting capabilities to address threat scenarios relevant for national security, including passively detecting improvised explosive devices (IEDs) and presence of biological pathogens in indoor and outdoor environments. These sensors will provide a flexible suite to complement conventional sensor systems within the DoD.			
FY 2021 Plans: - Integrate plant platforms to align threat detection with plant resource and ecology traits. - Develop a simulated environment containing co-occurring plant, insect, and microbial species representing realistic competitive, predator, parasitic, and mutualistic interactions. - Demonstrate the ability of engineered plants to sense and report exposure to threats in multiple simulated environments. - Examine molecular mechanisms of protein production in mature plants.			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
- Assess plant protein production outcomes and determine relevant phenotype characteristics. ***FY 2022 Plans:*** - Confirm plant sensor reporting phenotypes are detectable from stand-off post stimulus exposure. - Perform phenotyping of plant sensors under prescribed simulated biosecurity threat scenario. - Quantify plant sensor functionality by applying trace stimuli and evaluating response for high sensor sensitivity and specificity. - Evaluate altered plant physiological properties based on understood molecular mechanisms for desired outcomes. - Demonstrate protein production outcomes and analyze system for potential undesired effects. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** The FY 2022 increase reflects initiation of large-scale experimental simulation for integrated plant sensor testing.			
Title: Preemptive Expression of Protective Alleles and Response Elements (PREPARE)	30.097	16.899	14.585
Description: The Preemptive Expression of Protective Alleles and Response Elements (PREPARE) program is creating a transient, near immediate prophylaxis and treatment to protect military personnel and civilians against public health and national security threats. Currently, protection against Chemical, Biological, Radiological, and Nuclear (CBRN) threats relies on physical barrier technology. This program includes research to develop novel transient and reversible gene modulator therapies to bolster intrinsic host defenses. Work within this program will provide novel solutions that extend beyond the DoD's capabilities to respond to re-emerging, newly emerging, or engineered threats. ***FY 2021 Plans:*** - Refine Target Product Profile (TPP) to guide initial regulatory discussions and inform pre-clinical studies to determine efficacy of programmable gene modulator based medical countermeasures. - Determine optimal formulations to deliver programmable gene modulators to appropriate cells and tissues with high specificity and for threat-relevant periods of time. - Demonstrate and optimize specificity to targets, duration, and magnitude of programmable gene modulator activity in vivo. - Perform capability demonstration of programmable gene modulator platform to assess protection against a chemical, biological, or radiological threat in small animal models. ***FY 2022 Plans:*** - Refine formulations to deliver programmable gene modulators to appropriate cells and tissues with high specificity and for threat-relevant periods of time. - Refine specificity to targets, duration, and magnitude of programmable gene modulator activity in vivo. - Perform capability demonstration of programmable gene modulator platform to assess protection against a chemical, biological, or radiological threat in large animal models.			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
- Begin drafting pre-Investigational New Drug (IND) or Emergency Use Authorization (EUA) package for submission to the FDA. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** The FY 2022 decrease reflects reduction in research efforts associated with identifying effective gene targets for clustered regularly interspaced short palindromic repeats (CRISPR)-based medical countermeasures.			
Title: Persistent Aquatic Living Sensors ***Description:*** The Persistent Aquatic Living Sensors program is developing novel capabilities to sense and surveil submersibles (e.g., submarines, unmanned underwater vehicles) and divers in littoral waters using living organisms present in the environment. This effort focuses on characterizing marine biological behavior in response to targets of interest and developing the hardware, software, and algorithms that will translate organism behavior into DoD actionable information. By harnessing the unique capabilities of biology, including adaptation, response, and replication, work in this program will enable persistent dominance in contested waters. Results from this research will enhance security for maritime activities and provide DoD naval operations with new sensing paradigms to complement current sensor technologies used in traditionally challenging regions across the world. ***FY 2021 Plans:*** - Demonstrate approaches to evoke biological responses in marine organisms. - Characterize operational utility of biological responses in multiple environments. - Demonstrate biological responses to targets and confounders in more realistic environments, with greater discrimination fidelity. - Perform field experiments to characterize maximum sensory and response propagation distances of biological organisms. - Demonstrate full end-to-end system capability in near shore environments for detection, processing, and near real-time alerting to presence of manned or unmanned vehicles via seaworthy prototype. ***FY 2022 Plans:*** - Demonstrate improvements in approaches to evoke and characterize biological responses in marine organisms. - Test the accuracy of biological systems at various propagation distances in multiple environments. - Refine system improvements and validate performance in the presence of noise and surface vessel traffic. - Demonstrate the ability of second-generation prototype to detect, process, characterize and alert the presence of manned or unmanned underwater vehicles in near shore or open water environments. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** The FY 2022 increase reflects minor program repricing.	27.066	25.720	26.541
Title: Expanding Human Resiliency ***Description:*** The Expanding Human Resiliency program aims to maximize warfighter resiliency by leveraging the signals of the human microbiome to improve physiology. This program will develop new technologies to control and manipulate the microbiome	13.425	13.500	17.773

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
(e.g., to reduce attraction and feeding of disease vectors such as mosquitoes). Current state-of-the-art approaches are focused on metagenomics to inventory and categorize the microbes in a given sample. In order to have more precise and on-demand control of microbiomes, technologies will be developed to elucidate the complex interactions between the microorganisms and their host as well as the interactions between consortia of adapted and evolved microorganisms. Advances in this area will both develop novel technologies to interrogate complex microbial communities in human systems and discover ways to beneficially harness microbiomes to expand warfighter resiliency. ***FY 2021 Plans:*** - Optimize testing methods to alter chemical production by microbiomes. - Initiate testing using in vitro model communities to alter chemical production by microbiomes. - Validate alterations to chemical production to reduce attraction and feeding of mosquitoes or other disease vectors. - Investigate methods to improve physical and computational models of microbiomes. ***FY 2022 Plans:*** - Test integration and stability of altered microbial strains in vivo. - Investigate methods to deliver interventions to skin to alter chemical production by the microbiome. - Down select and refine targets for chemical production by microbiomes. - Validate alterations to chemical production to reduce attraction and feeding of mosquitoes or other disease vectors within in vitro model communities. - Refine and validate physical and computational models of microbiomes based on empirical data. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** The FY 2022 increase reflects initiation of efficacy and stability studies using animal models and initial studies toward development of topical (skin) formulations.			
Title: Restoring Cognitive Capability ***Description:*** The Restoring Cognitive Capability program is developing novel drugs to provide rapid therapy for neuropsychiatric disorders experienced by warfighters and veterans. Active duty military personnel face increased risk of acute and chronic neuropsychiatric dysfunction, limiting day-to-day function and return to duty. Current therapeutic approaches for many neuropsychiatric disorders (e.g., Post Traumatic Stress Disorder [PTSD], mood disorders, and substance abuse) rely on individual management with integrated psychiatric therapy and medication. However, most interventions approved for use in these conditions lack long-term efficacy, involve a logistical burden of treatment and/or carry a risk of serious adverse side effects. The Restoring Cognitive Capability program is developing and testing novel drug chemotypes designed to functionally interact with neuronal receptor subtypes known to play a role in these neuropsychiatric conditions, with the aim of enabling fast-acting and effective alleviation of neuropsychiatric dysfunction with single or minimal doses.	8.498	11.178	11.423

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
FY 2021 Plans: - Continue in vitro functional testing of novel molecules. - Develop novel biosensors for assessment of drug uptake and distribution. - Continue assembly and validation in vivo of behavioral assays. ***FY 2022 Plans:*** - Evaluate in vitro signaling effects of novel molecules. - Develop animal models with humanized neuronal receptor subtype. - Validate biosensors for assessment of drug uptake and distribution in vivo. - Test novel molecules for therapeutic actions and side effects in vivo. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** The FY 2022 increase reflects minor program repricing.			
Title: Food and Feedstocks on Demand ***Description:*** The Food and Feedstocks on Demand program is developing biological technologies to support the DoD need to strengthen local resource security for the warfighter. Currently, operators in the field are burdened with transport and disposal of single-use materials. This program is using these burdensome materials as inputs and re-form the molecules for nutrition or other strategic applications. Research in this program will provide a versatile system that delivers food, water, and petroleum/ oils/lubricants (POLs) so that warfighters can independently produce material support to extend mission duration and/or expand operational flexibility in resource-limited environments. ***FY 2021 Plans:*** - Design a prototype system to maximize the use of military waste for desired products. - Design chemical, biochemical, and biological treatments, and combinatorial processes to complement the deconstruction of waste in military operation scenarios. - Design extraction techniques to obtain purified chemical compounds from contaminated waste mixtures. ***FY 2022 Plans:*** - Breakdown plastic waste material into a biodegradable, detoxified environmentally compatible formulation. - Scale purification techniques to obtain desired products free from contaminants. - Optimize the process for product generation from increasingly complex plastic waste mixtures. - Demonstrate the capability to convert waste into usable materials for 24 hours. - Investigate methods to develop computational tools for alternate approaches to develop critical molecules and materials. ***FY 2021 to FY 2022 Increase/Decrease Statement:***	9.693	13.053	18.642

Exhibit R-2A, RDT&E Project Justification: PB 2022 Defense Advanced Research Projects Agency		Date: May 2021
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
The FY 2022 increase reflects addition of systems engineering and design deliverable to proof-of-concept.			
Title: Gene Editing Enabled Diagnostics & Biosurveillance	10.000	13.550	19.923
Description: The Gene Editing Enabled Diagnostics & Biosurveillance program is developing fieldable, low-cost gene editing-based diagnostics capabilities for rapid, specific, sensitive, and multiplexed detection of biological threats in military and public health scenarios. This program will investigate the design rules for diagnostic and biosurveillance targets to achieve broad-spectrum detection with high confidence diagnostic results. These design rules will inform advanced computational and machine learning approaches to scan genome data and algorithmically design probes and guides for optimal assay results. Additional work will develop assay architectures, reagents, and detection platforms to enable field-forward diagnostics at the point-of-care with the same sensitivity, and reliability tests conducted in hospital/central laboratories. ***FY 2021 Plans:*** - Begin to develop assays with multiplexed, clinically or environmentally relevant levels of detection sensitivity. - Investigate robust and reproducible detection in clinically or environmentally relevant sample matrices. - Refine computational design tools to inform the design and function of optimal diagnostic and biosurveillance assays. - Characterize failure modes of design and detection technologies. ***FY 2022 Plans:*** - Establish computational tools to create diagnostic and biosurveillance assays for a target biological signature. - Demonstrate assay utility for detection of targets in relevant clinical or environmental samples. - Develop prototype handheld devices for point-of-care and demonstrate detection of targets. - Develop prototype benchtop modules for highly multiplexed diagnostic and biosurveillance assays and demonstrate detection of targets. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** The FY 2022 increase reflects systems-level integration of components into a biosensor for disease detection and surveillance.			
Title: Unburdening the Warfighter from Chemical/Biological (CB) Defense	-	9.040	17.198
Description: The Unburdening the Warfighter from Chemical/Biological (CB) Defense program aims to increase warfighter survivability by developing improved personal protective equipment (PPE) and medical countermeasure (MCM) technologies to protect against CB threats. Current methods of CB protection require significant logistical burdens, including suits that are bulky and hot, which limit operational capability. These burdens increase if an increased level of protection is required. The Unburdening the Warfighter from CB Defense program will investigate and design novel biological and material approaches that provide rapid protection against multiple CB agents for the warfighter. This research will innovate PPE through the discovery of compounds			

Exhibit R-2A, RDT&E Project Justification: PB 2022 Defense Advanced Research Projects Agency		Date: May 2021
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
and lightweight, durable systems designed to capture, neutralize, or repel CB agents. This novel approach will provide almost immediate and lasting protection even in austere operational settings. ***FY 2021 Plans:*** - Coordinate with Independent Validation and Verification (IV&V) support teams to establish study designs, testing infrastructure, and standards compatible with FDA regulatory guidance. - Investigate approaches (e.g., special coatings, enzymes, biological) to neutralize or decontaminate Chemical or Biological agents. - Initiate development of novel system components to provide protection to vulnerable tissue barriers (e.g., skin, airway, and ocular). - Initiate platform component design in concert with regulatory and IV&V guidance for developing warfighter technologies. ***FY 2022 Plans:*** - Investigate formulations and delivery methods required to provide the warfighter with biological systems capable of mitigating threats. - Begin testing the ability of the system components to protect against exposure to CB threats using special coatings, enzymes and biological approaches. - Validate system components safety design in a simulated environment. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** The FY 2022 increase reflects the initiation of testing and safety validation of system components.			
Title: Atmospheric Water Extraction (AWE)	-	9.500	14.687
Description: The Atmospheric Water Extraction program aims to enable water harvesting directly from the atmosphere by leveraging new materials and advanced engineering and manufacturing techniques to alleviate the logistical and tactical burden of the water supply chain. Currently, the DoD relies on purification of existing water sources and/or distribution of bottled or treated water to provide the warfighter with sufficient daily hydration. State-of-the-art water-from-air generation systems are not suitable for military applications because the systems do not operate in a range of atmospheric conditions needed by our soldiers, from arid conditions (<40% relative humidity) to extremely humid, and are too energy-intensive (<7 gallons of water output per gallon of fuel). This program will deliver systems with extraordinarily low size, weight, and power (SWaP) characteristics to provide potable water to individual warfighters, and expeditionary units. Technologies developed under this program will provide strategic and tactical advantages aligned with the DoD's vision of future combat operations carried out by distributed and self-sustaining forces. ***FY 2021 Plans:***			

Exhibit R-2A, RDT&E Project Justification: PB 2022 Defense Advanced Research Projects Agency		Date: May 2021
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
- Begin development and optimization of sorbent materials with properties tailored to low-powered and rapid water capture and release. - Develop a component-level system model for an engineered water extraction device. - Initiate fabrication of components of modeled water extraction device. ***FY 2022 Plans:*** - Optimize and refine water capture and release with developed sorbent materials. - Integrate sorbent materials with components of modeled water extraction device. - Test and evaluate fabricated components of modeled water extraction device. - Demonstrate initial prototype water extraction device under program test conditions. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** The FY 2022 increase reflects development of system components and optimization for prototype integration.			
Title: Bio-Inspired Coastal Defense ***Description:*** Building upon technologies discovered in the Persistent Aquatic Living Sensors (PALS) program, the Bio-Inspired Coastal Defense program will develop self-sustaining, hybrid man-made and biological reef structures to fortify and defend DoD bases in low-lying coastal regions. Military assets in these coastal regions are vulnerable to storm surges, wave action, and sea-level rise that cause erosion, degrade infrastructure, and impede operations. Innovative coastal defense will require major technological advances in (1) design, construction, and placement of manufactured reef primers, (2) accelerated recruitment and/or growth of reef species, and (3) sustained, zero-cost natural maintenance and improvement (e.g., increased durability after challenge) of the defensive reef. The primary benefit of such structures is to attenuate wave height during storm events for both established and under construction coastal facilities. This approach could also mitigate ongoing threats posed by state and non-state actors that seek to penetrate, mine, or damage harbors using unmanned underwater vehicles as delivery mechanisms. ***FY 2022 Plans:*** - Design and fabricate structural components to achieve target wave energy attenuation in wave tank simulations. - Demonstrate the efficacy of reef-building approaches under laboratory conditions. - Conduct laboratory experiments to promote improved temperature tolerance for reef-building organisms. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** The FY 2022 increase reflects program initiation.	-	-	11.490
Title: Environmental Microbes as a Bioengineering Resource (EMBER) ***Description:*** The Environmental Microbes as a Bioengineering Resource (EMBER) program will seek to leverage microbial processes to enable new methods of discovery, design, and/or production of critical materials used by the DoD. This program	-	-	8.764

Exhibit R-2A, RDT&E Project Justification: PB 2022 Defense Advanced Research Projects Agency		Date: May 2021
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
will leverage capabilities of microbes from extreme environments for processing inorganic materials not typically associated with biology to serve as platforms for discovery, engineering, and production. Efforts will elucidate and exploit biomolecular mechanisms for binding and biomineralization of inorganic elements (e.g., rare earth elements, metals) and utilize computational and high-throughput experimental methods to accelerate prototyping of microbe-assembled functional inorganic nanomaterials (e.g., optoelectronic, magnetic materials). Advances in this area will deliver capabilities to assure access to DoD-critical materials domestically or in operational settings. ***FY 2022 Plans:*** - Identify novel organisms, gene pathways, and microbial chemistries required for biomineralization of rare earth elements. - Begin development of synthetic biology tools to engineer organisms or adapt current chassis to rare earth elements. - Initiate studies of microbes that operate in high temperature and acidic conditions. - Initiate studies of microbial extraction of specific rare earth elements from simulated source materials at relevant concentrations. - Explore ability to genetically engineer microbes to assemble functional inorganic nanomaterial architectures. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** The FY 2022 increase reflects program initiation.			
Title: Genome Protection Technologies ***Description:*** The Genome Protection Technologies program is developing advances in critical efforts to generate a biodefense capability to control, counter, and reverse the effects of accidental or malicious misuse of gene editing technologies. This research is investigating new approaches for developing tunable controls to enable the safe and predictable use of synthetic genes and pathways. Additional work will develop protecting measures to prevent or limit unintended genome editing or engineering and develop new tools to recall or reverse engineered changes. Advances within this program will ensure that the U.S. remains at the vanguard of this now widespread, rapidly advancing field that poses potential national security threats due to the large-scale democratization of gene editing technologies. ***FY 2021 Plans:*** - Demonstrate efficient and specific target gene removal in vivo within a simulated natural environment. - Demonstrate safe, specific, stable, and highly-efficient genome editors and controllers in vivo for therapeutic applications. - Demonstrate effective and safe application of genome editing inhibitors in vivo. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** The FY 2022 decrease reflects program completion.	13.584	10.296	-
Title: Defend Against Crop System Attack	12.718	8.498	-

Exhibit R-2A, RDT&E Project Justification: PB 2022 Defense Advanced Research Projects Agency		Date: May 2021
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Description: The Defend Against Crop System Attack program is developing a platform technology aimed at increasing the speed of DoD response to state or non-state actor release of biological threats directed at our crop systems. Conventional methods to defend against these threats are generally slow and ineffective. This program will leverage recent advances in molecular and synthetic biology to enable rapid delivery of gene therapies to plants for large-scale trait modification, improving resilience against adversary attack or emerging natural threats. Research within this program will develop an agnostic, scalable capability for protecting entire crop systems from emerging threats posed to food security by U.S. adversaries. ***FY 2021 Plans:*** - Demonstrate successful insect delivery of a virus to targeted plants in a diverse plant community, without off-target effects, in a contained environment. - Employ and validate conditional lethal approach restricts viral delivery and limits propagation of virus, insect, and plant trait acquisition. - Verify protective traits delivered to a diverse plant community results in mitigation of an environmental stressor. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** The FY 2022 decrease reflects program completion.			
Title: Enhancing Neuroplasticity ***Description:*** The DoD needs tools to rapidly and effectively train military personnel in multifaceted and complex tasks. The Enhancing Neuroplasticity program explored and developed peripheral nerve stimulation methods and non-invasive devices to promote synaptic plasticity for improved learning paradigms. Key advances from this research include an anatomical and functional map of the underlying biological circuitry that mediates plasticity, as well as successful stimulation and training protocols to enable long-term retention for military personnel. Underlying mechanisms of targeted plasticity training were successfully identified and leveraged to inform intervention parameters that have been applied to a broad range of cognitive skill training within the DoD, including foreign language learning and intelligence analysis.	8.543	-	-
Accomplishments/Planned Programs Subtotals	149.414	147.066	179.698

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A