|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **TRL-0** | **Conceptualized**  A perceived need or possible desired outcomes has been broadly described and a possible approach to satisfying the need or achieving the desired outcomes is conceived. | | | | |
|  |  | | | | |
|  | **Examples – Medical Drugs** |  | **Examples – Medical Devices** |  | **Examples – Non-Medical** |
|  | * The need to develop vaccines faster without having to grow weakened forms of a virus and the possibility that mRNA can be used to accomplish the objective. * Research discussed in the literature suggesting that modified mRNA could be used to create vaccines against various viruses and bacteria without concern about low stability or strong immunogenicity. |  | * The need to detect hemorrhages earlier than the current standard of care to enable faster intervention and the possibility that an approach based on monitoring peripheral blood flow and blood content can accomplish the objective. * Research discussed in the literature that suggests hemodilution can be detected noninvasively. |  | * The need to address drinking water scarcity and the possibility that water can be extracted from the air to accomplish this objective. * The need to make cleaning water filtration membranes easier and the possibility that a different water filtration membrane could achieve this objective. |
|  |  |  |  |  |  |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **TRL-1** | **Theoretical Feasibility Demonstrated**  The relevant phenomena and basic scientific principles have been identified. Experimental data and theoretical analysis demonstrate that it is feasible for the technology to achieve the desired outcome. | | | | |
|  |  |  |  |  |  |
|  | **Examples – Medical Drugs** |  | **Examples – Medical Devices** |  | **Examples – Non-Medical** |
|  | * Identification of COVID-19 as a target indication and development of the basic approach for using mRNA to create a vaccine against the virus that causes it. * An *in silico* immune simulation of a potential vaccine against Mycobacterium tuberculosis. * Experiments showing that PI3K/phosphate and fungi homology deleted on chromosome 10 (PTEN)/AKT/TSC pathway (a signaling pathway in which gene mutations can lead to malignant tumors) is the main activator of mammalian target of rapamycin complex one (mTORC1), which regulates cell growth and metabolism. |  | * Identification of postpartum hemorrhage as a target indication and a conceptual design of a device for detecting postpartum hemorrhage based on monitoring peripheral blood flow and blood content. * Laboratory experiments that demonstrate the available optical technologies can be used to noninvasively measure blood flow and blood content to detect postpartum hemorrhage. * In developing nerve stimulation technology to manage various diseases by excitation or inhibition of the sympathetic nervous system, experiments on rats demonstrate the sympathetic nerve can be stimulated from at least 4 mm away, but the experiment does not demonstrate treatment of a specific disease. |  | * Sketching of a working scheme for a crumpled graphene-based reactive filtration membrane. * Experiments that demonstrate a single-step aerosol method can be used to synthesize crumpled nanocomposites of crumpled graphene oxide (CGO) and that a variety of functional materials can be incorporated via encapsulation. * A conceptual sketch of a heat exchange system for extracting clean drinking water from air. * Calculations that show the performance requirements of a heat exchange system for extracting clean drinking water from air are attainable. |
|  |  |  |  |  |  |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **TRL-2** | **Proof-of-Concept Demonstrated**  The elements of the technology have been integrated into prototypes comprising the key features, basic form, and desired functionality. Tests of the prototypes in laboratory and simulated environments provide additional evidence that the technology is likely able to achieve the desired outcome. | | | | |
|  |  |  |  |  |  |
|  | **Examples – Medical Drugs** |  | **Examples – Medical Devices** |  | **Examples – Non-Medical** |
|  | * An in vitro study showing that the antibodies from people who have received the Pfizer-BioNTech COVID-19 vaccine effectively neutralize SARS-CoV-2 with a key mutation that is also found in two highly transmissible strains. * An in vitro study demonstrating that alpha nucleotidyl transferase (HT) enzymes have high potential as anti-Cryptococcus neoformans agents. * A study for developing a vaccine for Mycobacterium tuberculosis (Mtb) that shows the compound 4-Aminoquinolone piperidine amides targets DprE1 and has good solubility, strong activity against replicating Mtb, and an acceptable secondary pharmacological profile. * A study in which new lipid nanoparticle mRNA COVID-19 vaccine candidate protected 70 percent of mice expressing the human angiotensin-converting enzyme 2 (ACE2), while all the non-vaccinated mice died. |  | * A rudimentary hemodilution detection device for noninvasively detecting postpartum hemorrhage that is fabricated from off-the-shelf components and demonstrates the key functionality of noninvasively measuring blood flow and blood content but lacks the desired form of the envisioned device and certain functionality such as remote monitoring. * A refined prototype of a hemodilution detection device for noninvasively measuring blood flow and blood content to detect postpartum hemorrhage that is in the form of the envisioned device and demonstrates all the functionality of the envisioned device. |  | * A benchtop demonstration system that shows crumpled graphene oxide nanocomposites encapsulating titanium dioxide (TiO2) and silver (Ag) can exclude a model organic and a model protein and maintain the minimum required water flux for a commercial application. * A commercial grade crumpled graphene oxide nanocomposite water filtration membrane is produced in a one-off batch process and tested in the laboratory. * A prototype heat exchange water extraction system constructed from off-the-shelf components that demonstrates the desired functionality but is not in the envisioned final form. * A one-off prototype heat exchange water extraction system that is in essentially the envisioned form and exhibits all intended functionality is constructed and tested in the laboratory. |
|  |  |  |  |  |  |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **TRL-3** | **Application Viability Demonstrated**  High-fidelity or full-scale prototypes close to the envisioned final form and functionality have been sufficiently tested in the intended environment or suitable facsimiles and have achieved the desired outcomes with sufficient consistency. | | | | |
|  |  |  |  |  |  |
|  | **Examples – Medical Drugs** |  | **Examples – Medical Devices** |  | **Examples – Non-Medical** |
|  | * A Phase I trial of a compound for the potential treatment of obesity that comprised 41 subjects and demonstrated the safety, tolerability, and clinical effect of single and multiple doses as well as escalating doses of the compound. * A Phase II trial of an adenosine triphosphate-competitive and reversible inhibitor of aurora kinase A that comprised 91 subjects with endocrine-resistant, HER2-negative metastatic breast cancer who were previously treated with fulvestrant, which demonstrated the efficacy, response rate, and optimal dosing regimen of the treatment. |  | * A refined prototype of a hemodilution detection device for noninvasively measuring blood flow and blood content to detect postpartum hemorrhage that is in the form of the envisioned device, demonstrates all the functionality of the envisioned device, and is tested in a swine model of hemorrhage. * A preproduction prototype of a postpartum hemorrhage detection device that has undergone design verification, been constructed using defined manufacturing processes and practices, and been appropriately tested on human patients. |  | * In developing a crumpled graphene oxide nanocomposite water filtration membrane a demonstration of in situ synthesis of nanoscale silver (nAg) particles by crumpled graphene oxide titanium dioxide (GO–TiO2 or GOTI) nanocomposites as an approach to generate and regenerate enhanced antimicrobial activity over extended operation times. * Manufacturing processes for a crumpled graphene oxide nanocomposite water filtration membrane is defined and pre-production units are produced, and field tested. * The manufacture of pre-production units of a heat exchange water extraction system using the specified production processes and field testing of the system in an arid location. |
|  |  |  |  |  |  |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **TRL-4** | **Sufficiently Mature for Intended Use**  No further major modifications are necessary, and the technology is ready to be implemented in the intended environment. | | | | |
|  |  |  |  |  |  |
|  | **Examples – Medical Drugs** |  | **Examples – Medical Devices** |  | **Examples – Non-Medical** |
|  | * A Phase III trial of a prostate cancer treatment that targets androgen receptor signaling which comprised 1,311 subjects with metastatic castration-resistant prostate cancer (mCRPC) and demonstrated the radiographic progression-free survival (rPFS) and overall survival (OS) improved to a statistically significant degree. * Ready to prepare and submit new drug application (NDA) to the U.S. Food and Drug Administration (FDA). |  | * Validation testing of a production prototype has been performed to provide the necessary evidence to evaluate the safety and effectiveness of the device required for the approval pathway. * Ready to prepare and submit application to market medical device to the public to the U.S. Food and Drug Administration (FDA). |  | * A production model is ready to be implemented in an intended environment. * Only minor fixes or changes are required to address small, non-critical problems identified following market introduction. * A production unit of a heat exchange water extraction system is field tested at a camp in the Mojave Desert. |