**State of
New Jersey
Commission on
Spinal Cord
Research**

DIRECTORY OF GRANT AWARDS
2018 GRANT CYCLE

NEW JERSEY COMMISSION ON SPINAL CORD RESEARCH

2018 GRANT CYCLE

DIRECTORY OF GRANT AWARDS FOR SPINAL CORD INJURY AND DISEASE RESEARCH

JUNE 2018

NEW JERSEY COMMISSION ON SPINAL CORD RESEARCH

This data was compiled in compliance with the New Jersey Commission on Spinal Cord Research's statutory mandate, N.J.S.A. 52:9E-1, "…to compile a directory of spinal cord research being conducted in the State."

The information contained within this directory is not all-inclusive. The research projects and researchers listed in this directory are all based in the State of New Jersey and have applied to and received funding during the fiscal year 2018 grant cycle. The research projects are not categorized, or listed in any order.

This directory is not a complete listing of all scientific research being performed within the State of New Jersey due to the proprietary nature of the research being conducted at various institutions throughout the State. In addition, institutions are not obligated to share their research information with the New Jersey Commission on Spinal Cord Research.

Please feel free to contact the New Jersey Commission on Spinal Cord Research at P.O. Box 360, 369 S. Warren Street, Trenton, New Jersey, 08625. The Commission's office can be reached by telephone at 609-292-4055, by fax at 609-943-4213, or by e-mail at NJCSCR@doh.nj.gov.

For information on the New Jersey Commission on Spinal Cord Research's grant award process, grant applications and deadlines, please see: www.state.nj.us/health/spinalcord.

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INDIVIDUAL RESEARCH GRANT RECIPIENTS:

CSCR18IRG013
Nancy Chiaravalloti, Ph.D.
Kessler Foundation
$557,782

Examining Behavioral and Neural Aspects of Implicit Procedural Learning Performance in Individuals with Spinal Cord Injury

This study will characterize implicit procedural learning deficits in SCI and explore cognitive and neural underpinnings of this ability, which is critical for optimal learning in rehabilitation.

Traumatic spinal cord injury (SCI) is a significant public health concern as it affects approximately 11,000 individuals in the US per year, who incur lifetime costs ranging from $1.1 to $4.7 million each. Recent research indicates that many individuals with SCI have problems with cognition. Cognitive problems can be detrimental for daily living and limit independence, thus leading to poor health outcomes and low quality of life. An important aspect of cognition is our ability to be able to learn things and perform them automatically, such as for example, learning to ride a bike or type on a keyboard efficiently. This cognitive process is called implicit learning and relies not only on the brain but also involves the spinal cord. Implicit learning is very important for achieving successful rehabilitation outcomes. It is during rehabilitation individuals try to relearn lost function so they can do certain things automatically again. Thus, deficits in implicit learning can greatly hinder rehabilitation in individual with SCI.

Despite its direct relevance to rehabilitation, little is known about implicit learning in individuals with SCI and how their brain functions when implicit learning is required. Thus, the objective of the proposed study is to examine implicit learning in individuals with SCI. The proposed study utilizes functional magnetic imaging (fMRI) and neuropsychological testing to examine implicit learning in individuals with SCI, how implicit learning is related to other cognitive processes, and whether implicit learning relies on different brain regions in comparison to healthy individuals. The results of this investigation will lay the basis for the development of informed treatment strategies to improve implicit learning in persons with SCI as the development of the most effective intervention relies upon a complete and multifaceted understanding of the sources of the deficit.

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NEW JERSEY COMMISSION ON SPINAL CORD RESEARCH

CSCR18IRG014
Jeanne Zanca, Ph.D.
Kessler Foundation
$589,471

Informing Identification of Neuropathic Pain Phenotypes in People with SCI

The proposed study will provide the preliminary data needed to design, fund, and implement the large-scale, multi-center studies that are required to establish neuropathic pain phenotypes.

WHY IS THIS STUDY BEING DONE? Neuropathic pain is a type of pain that is associated with injury or malfunction of the nervous system. This common complication of SCI usually develops in the first-year post-injury. Neuropathic pain decreases quality of life and is very difficult to treat. Neuropathic pain characteristics (the way it feels, when it is better or worse, what changes in sensation accompany the pain, etc.) vary widely among people with SCI. There are many types of medicines for neuropathic pain that work in different ways, and we do not know which medicines are best for which types of neuropathic pain. We expect that people with SCI who are similar in how their sensory systems are functioning and how their pains feel are likely to have similar causes for their pain.   We need a way to identify groups of people who are similar to one another in their pain-related characteristics (their "neuropathic pain phenotype") so that we can test different medicines in these groups of people and find the ones that work best for their particular type of pain.

WHAT WILL THE STUDY TEACH US? Identifying subgroups of people whose neuropathic pains have common features (their "neuropathic pain phenotype") requires studies with large numbers of people that can only be done if several research centers or hospitals work together. To determine how many people we need to enroll in such a study, we need to estimate the percent of people who will likely develop neuropathic pain in the first year and what type of pain they develop (pain at the level of their spinal cord injury or pain below that level). We also need to know how many people may drop out of the study. Other important information that is needed to plan a future study includes which characteristics of pain are different among people with different types of pain, because these characteristics will help us define pain phenotypes. Finally, we need information about how sensory and pain characteristics change over time to identify the kinds of information we should collect in a large-scale study to identify characteristics that can predict the start or end of neuropathic pain and to understand how neuropathic pain phenotypes may change over time.

WHAT WILL HAPPEN IN THE STUDY? In this study, we will enroll 54 adults with new, traumatic SCI who are receiving rehabilitation at Kessler Institute for Rehabilitation. The participants will have three evaluations: one each at 1, 6, and 12 months after SCI. During these evaluations, participants will (1) complete questionnaires to describe the presence of pain and its characteristics, (2) be examined by a doctor to classify the type of SCI they have, and (if applicable) what type of pain(s) they have developed, and (3) undergo an assessment in which different kinds of stimulation (warm, hot, cold, dull, sharp) will be provided to the skin to see how their body's sensory system is responding.

HOW WILL THIS STUDY BENEFIT PEOPLE WITH SCI? The proposed study will provide the information we need to conduct large-scale studies to identify neuropathic pains with common features ("neuropathic pain phenotypes"). In turn, these phenotypes can be used to study different medicines in different types of pain so that we can determine which medicines are effective for which pains, and provide physicians with the evidence they need to match patients to the treatments that are most likely to be helpful to them. Better treatment of neuropathic pain will substantially improve quality of life for people with SCI.

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NEW JERSEY COMMISSION ON SPINAL CORD RESEARCH

CSCR18IRG007
Martin Yarmush, Ph.D.
Rutgers University
$600,000

Microencapsulated Nanoparticles and Genetically Modified MSC for Treatment of SCI

Chemically transfected and PLGA alginate co-encapsulated MSC will reduce glial scarring and provide anti-inflammatory and neuroregenerative factors for SCI therapy.

Each year 12,000 new cases of spinal cord injuries (SCI) are reported throughout the U.S with the total number of patients exceeding 1 million, and over 6000 of these reside in NJ. The life changing consequences of SCI are not only due to the initial mechanical injury but the secondary events that follow the initial catastrophic event. The primary mechanical trauma initiates a secondary cascade of events, resulting in inflammation, scar tissue generation and ultimately the inability of the damaged neuronal axons to reconnect. Hence destruction of spinal cord tissue ensues, with functional losses that are life changing both physically and financially. Thus far, molecular treatments which focus on controlling inflammation, disrupting scar tissue formation or promoting axonal regeneration, have not demonstrated sufficient clinical efficacy and therefore, there is a significant need for the development of new multi-modal therapies.

An expanding body of literature evidence suggests that transplanted multi-functional mesenchymal stromal cells (MSC) can improve functional SCI outcomes as they secrete a plethora of anti-inflammatory cytokines and tissue regenerative growth factors. However, limitations with direct implantation of MSC include the fact that millions of infused MSC are needed to offset the loss of cells to non-targeted tissues and decay in response to the complex injury environment. To address this concern, our lab previously developed an alginate encapsulation (eMSC) approach that sustains MSC viability and promotes constitutive secretion of a panel of anti-inflammatory factors. Alginate is a cost effective, non-immunogenic, FDA-approved material that has been utilized extensively for a variety of stem cell differentiation and cell immobilization protocols. While these cells can significantly reduce tissue inflammation post-SCI, they are less effective at promoting neuronal regeneration because they do not directly control scar tissue formation, nor do they secrete large enough levels of neuroregenerative factors such as Brain Derived Neurotrophic Factor (BDNF), one of the molecules which has been shown to extend neuronal axons after SCI.

Therefore, we propose to augment eMSC function by transfecting the cells with a safe, non-viral vector that will promote the secretion of chondroitinase, an enzyme which can impede scar tissue formation. We will stabilize the enzyme by co-encapsulating our MSC with nanoparticles that contain the sugar, Trehalose, which is known to preserve protein enzymatic and molecular function. In addition, we will also include nanoparticles containing BDNF to improve the regenerative function of our cell therapy. Therefore, we expect to generate a novel, multi-modal and cost-effective cell therapy for SCI treatment.

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EXPLORATORY RESEARCH GRANT RECIPIENTS:

CSCR18ERG028
Silvana Lopes Costa, Ph.D.
Kessler Foundation
$194,306

Using Eye-Tracker based Cognitive Assessments to Examine Cognitive Functions in SCI

This project aims to develop and test an eye-tracking based ("hands-free") cognitive assessment to overcome the challenges imposed by upper limb motor dysfunction common in spinal cord injury. Cognitive functions (the ability to execute mental operations) are often impaired among persons with spinal cord injury (SCI) and are estimated to affect up to 60% of persons who live with SCI. One of the biggest challenges when developing protocols to assess cognitive functioning in persons with SCI is that many of the measures require upper limb function to respond properly (e.g. hand pointing, typing, squeezing, etc). In fact, in our ongoing studies examining cognitive functions in SCI, funded by the New Jersey Commission on Spinal Cord Research, enrolled participants demonstrated significant difficulties executing cognitive tasks that require a motor response. Clinicians and researchers are thus limited in regard to the available tests they can use to assess cognitive functions in persons with SCI. This is particularly important because a detail assessment of cognitive abilities is essential to fully understand the impact of the SCI and plan an effective multidisciplinary rehabilitation program. Thus, it is fundamental that we develop new methods to assess cognitive functions that can be use with all individuals with SCI, independent of their level of motor functioning.

The present proposal aims to develop and test an eye-tracker based ("hands-free") cognitive assessment that instead of using the upper limbs to provide a response, requires participants to provide responses by fixating their eyes in specific locations on a monitor. This technology has been used in the past with high success in other populations with similar motor disabilities. This is an innovative project that will allow clinicians and researchers to assess cognitive functions in persons with SCI independently of upper limb functioning. It will have a huge impact on our ability to assess and understand cognitive impairments in SCI. A detailed evaluation of cognitive functions is fundamental to understanding who may need to engage in cognitive rehabilitation programs and thus this project will significantly contribute to improved care and increased quality of life of those who live with SCI. The proposed project will directly contribute to the assessment and treatment of a secondary condition resulting from SCI by applying a new approach to cognitive assessment, thus directly addressing the goals of the NJCSCR. We will meet the proposed objective through a 2-phase study. Phase I will develop an eye-tracker based cognitive assessment (ETCA) and execute a proof-of-principle study with 10 healthy controls (HC). Phase II will assess the sensitivity and usability of the ETCA in 20 individuals with SCI and 20 HC, and will also examine the impact of cognitive impairment on employment and quality of life in SCI. The development of a comprehensive neuropsychological evaluation that is completely motor-free ("hands-free") is fundamental to allow us to: (1) examine the prevalence of cognitive impairments associated with SCI, an under- studied area; (2) understand the impact of cognitive impairments on employment and quality of life in SCI; and (3) develop rehabilitation programs which can have a significant positive impact on the life of those who live with SCI. Thus, our proposal not only targets a relatively under-studied area in SCI care, but also has the potential to directly contribute to improved care of those who live with SCI—a priority for the NJCSCR. The findings resulting from this study will be used as leverage to apply for and obtain additional funding from federal and non-federal institutions to run a more comprehensive study (larger sample size) examining the efficacy and sensitivity of the eye-tracker based cognitive assessment in SCI and thus contribute to better and more efficient assessment practices of cognitive functions in SCI.

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NEW JERSEY COMMISSION ON SPINAL CORD RESEARCH

CSCR18ERG004
Soha Saleh, Ph.D.
Kessler Foundation
$199,988

Cortical Control of Walking; Brain Plasticity Following Exoskeleton Training in Incomplete Spinal Cord Injury

This exploratory study aims to detect brain signals during walking and determine the effect of exoskeleton training on brain plasticity using mobile brain imaging techniques. Despite the significant advancements in the rehabilitation interventions in spinal cord research, recovery of walking after spinal cord injury is still a challenge. In this proposal, we suggest that the brain plays a significant role in the control of walking, at least in the intention and planning to move. Studying the brain control of walking is fundamental as a basic science question and for the advancement of spinal cord research. Hence, we intend to use mobile imaging (in specific Electroencephalography (EEG)) techniques to establish the relationship brain activity and walking in able-bodied and individuals with sustained incomplete Spinal Cord Injury (iSCI), and study the change in brain activity after rehabilitation intervention using exoskeleton-walking robot (EWR).

Ten able-bodied individuals and ten individuals with iSCI subjects will be recruited for a single EEG testing session to record brain and muscle activity while the subjects are sitting, standing, and walking in an open space environment. Similarly, a group of 8 iSCI subjects, who are receiving training using exoskeleton walking robots at Kessler Foundation, as part of a federally funded project, will be tested using EEG before and after 20 and 40 sessions of training. Data will be collected and analyzed similar to able-bodied data, and statistical tests will be applied to contrast the cortical and cortico-muscular activity between the three testing sessions (before and after 20 and 40 hours of training). EEG data will be analyzed to establish the correlation between brain activity and sitting, standing, and each phase of walking. Further, connectivity within the brain (between brain regions that controls movement), and between the brain and the muscles will be studied. Statistical tests will be applied to compare the brain activity and coherence in brain and muscle activity in able-bodied and iSCI participants and study how this activity and coherence changes in iSCI participants after training. We will also look into possible effect of using an exoskeleton on brain and muscle activity in both able-bodied and iSCI participants, and if this effect changes based on the type of exoskeleton assistance during walking. In able-bodied subjects, we hypothesize that the brain initiates the intent to walk and contribute to the initiation and planning of steps and that the connectivity within the brain and between the brain and the peripheral muscles varies according to the phase of the walking cycle. In the iSCI subjects, we expect to find weaker cortical activity during standing and walking than in able-bodied subjects. After exoskeleton assisted walking training, we expect a reorganization in this activity. Finally, we expect that brain activity will be higher during walking with lower levels of robot-assistance since the individual will have more control on walking.

In summary, this proposal aims to apply brain imaging techniques to study the neural correlates of walking in able-bodied and iSCI subjects and explore the potential modulatory effect of exoskeleton training on brain activity. The aims of this study agree with the NJCSCR objective to "facilitate the application of innovative ideas from other areas of science to the challenges of spinal cord injury repair." This study also meets the NJCSCR priority to study strategies to promote neural plasticity, since it is the first study to use brain imaging to study change in connectivity within brain and between the brain and muscles after exoskeleton assisted walking training in iSCI, which is an indirect measure of formation of new direct and indirect connections in the brain and between the brain and the muscles. This study will provide pilot data to start larger research projects that look into the use of innovative rehabilitation strategies to promote the recovery of brain-muscle connectivity and to translate these findings into clinical settings.

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CSCR18ERG018
Sridhar Kannurpatti, Ph.D.
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$194,000

Mitochondrial Calcium Homeostasis and Translatable Outcomes in Spinal Cord Injury

Energetic and mitochondrial stress lead to secondary injury after SCI, which can be mitigated by early stage mitochondrial treatment to protect energy production and improve SCI outcome. Every year approximately 11,000 people sustain a traumatic spinal cord injury (SCI) in the United States, which results in over 200,000 people living with debilitating levels of chronic physical disabilities. New Jersey accounts for at least a few thousands of surviving SCI patients. While spinal injuries occur at different levels, cervical spinal injuries are the most frequent (about 62%) (http://www.uab.edu/medicine/sci/). SCI patients are clinically monitored using radiological and sometimes with functional imaging of the spinal cord and the brain combined with behavioral assessments of sensory and motor abilities. If treatments directed against SCI are to advance, they need to be tested for their effectiveness in restoring spinal circuit functions and its brain functional connectivity. Furthermore, relevant animal models of cervical SCI need to be characterized using similar clinical biomarkers applied in cervical SCI patients using imaging-intensive approaches. Towards this goal, we pioneered the application of functional neuroimaging (i.e., imaging certain physiological changes in response to neuronal activity in a non-invasive manner in the intact subject) using optical imaging and magnetic resonance imaging (MRI) technologies. We demonstrated brain functional changes after traumatic brain injury (TBI) in a rat model to evaluate treatments targeting mitochondria, which are subcellular organelles that generate energy molecules within cells. We discovered that facilitating mitochondrial function by improving its metabolism improved TBI outcomes. As similar excitotoxic (over excitability of neurons resulting in their death) secondary injury mechanisms exist in the brain and spinal cord, proposed exploratory studies will target spinal cord mitochondrial function by maintaining its energy metabolic capacity and ion homeostasis, which are depressed during the early stage (hours to few days) after injury. Functional imaging will be performed to assess spinal cord gray/white matter microstructure and vascular function through blood flow changes with and without mitochondrial treatments and correlated with brain connectivity changes. Metabolomic, histologic and behavioral assessment with and without mitochondrial treatment will also be obtained and correlated with imaging. The proposed studies will develop robust and translatable approaches for preclinical assessment of cervical SCI, which is the most prominent type of SCI. The developed imaging intensive approach will significantly help new treatment development and efficiently test therapies improving mitochondrial function for cervical SCI patients.

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CSCR18ERG015
Melitta Schachner, Ph.D.
Rutgers University
$200,000

Role of MARCKS-derived Peptide in Functional Recovery after Spinal Cord Injury

Impact of a MARCKS peptide known to bind to regeneration conducive PSA glycan will be studied in spinal cord injured mice receiving this peptide by minimally invasive controlled delivery to the injury.

Cell adhesion molecules are not simply a "glue" between cells, but ensure that the right cells connect with each other not only during development of the nervous system but also in learning and memory and regeneration in the adult. The search for and identification of the functions of cell adhesion molecules in regeneration is of prime importance for implementing cures. We have been able to identify a new pro-active adhesion molecule (called MARCKS) which interacts with another pro-active structure (a sugar, called polysialic acid). This sugar, attached to adhesion molecules, is important for recovery of the nervous system after trauma. In parallel with elucidating the functions of the active site of MARCKS, we will search for small compounds that mimic the beneficial functions of MARCKS to improve functional recovery after spinal cord injury. Having shown in preliminary data that MARCKS has the potential to be beneficial in mouse spinal cord injury, we now plan to gain more insights into the mechanisms by which this molecule functions. We also aim at identifying small organic compounds that mimic the functions of MARCKS with the hope that they can be targeted to the injured nervous system in clinical trials. Our studies will be important not only for many citizens of New Jersey, but also worldwide.

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CSCR18ERG009
Lori R. Covey, Ph.D.
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$200,000

Modulating CD4 T Cell Helper Function as a Therapeutic Response to Spinal Cord Injury

The role of CD40L in driving inflammation in spinal cord injury. We plan to investigate the therapeutic effects of decreased expression of CD40L in a mouse model of spinal cord injury (SCI). The spinal cord is a group of nerves that run from the brain down the vertebral column. The cord connects the brain with the rest of the body, making it an essential component for proper function in vertebrates. One important aspect of SCI that can lead to further damage is the inflammatory response that occurs following the injury. This inflammatory response is a result of many different cell types that reside in the central nervous system as well as cells, including CD4 T cells that enter the spinal cord from the blood. The primary function of CD4 T cells is to "help" other cell types carry out critical immune functions. One important way that they do this is by expressing a molecule on their surface called CD40L that interacts with CD40 expressed on many cell types in the injury site. They also express critical molecules called "cytokines" that inform other cells to respond in a particular way. The interaction between CD40L and CD40 is known to result in the expression of many different immune modulators; many of which exacerbate the injury and make recovery more difficult. Importantly, we have developed a mouse model that expresses less CD40L due to a mutation in the gene that alters the expression of the CD40L protein. Because we have not deleted CD40L, we find that CD4 T cells can still participate in helper function but not to the extent of unmutated CD4 T cells that express normal levels of CD40L.

We will use this mouse model to analyze a number of parameters of SCI. First, we will look at how this mutation affects the cells that are expressing inflammatory mediators that are detrimental to recovery. Second, we will determine which cell types are the most vulnerable to reduced levels of CD40L. Third, we will measure functional recovery in neurons from the site of injury using techniques that measure both their ability to survive and specific electrical responses of the nerve cells that are indicative of cells that are still able to function. We expect novel information from these studies to reveal the significance of CD40-CD40L in SCI recovery and lead to new knowledge regarding the use of this pathway in developing future therapeutics for SCI treatment.

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NEW JERSEY COMMISSION ON SPINAL CORD RESEARCH

CSCR218ERG017
Antonio Merolli, M.D.
Rutgers University
$200,000

A Device-assisted Surgical Procedure to Provide a Controlled Biophysical Environment for Spinal Cord Regeneration

To obtain spinal cord regeneration by a new surgical procedure centered on an implantable degradable device which will provide a protective biophysical environment. The spinal cord transmits signals back and forth to the brain and the rest of the body. Millions and millions of small cellular cables, the "nerve fibers", are assembled to form the spinal cord. This key structure is protected inside a robust canal (the "spinal canal") formed by the vertebral bones (the "spinal column"). However, major trauma can break even this strong bony protection. Sometimes it is an external body that produces the damage (a bullet in a gunshot wound); other times fractured vertebrae can produce bony fragments that literally cut the spinal cord into pieces. Blood pouring out from ruptured vessels (inside and outside the spinal cord) floods the spinal canal and its surroundings. A reparative process starts to take place immediately, but it is similar to attempting to repair a power cable during a hurricane. Furthermore, cells which provide a relay for signal transmission (neurons) and cells which provide support (glial cells), start to suffer from the reduction in oxygen flow and nutrients. As they die, they release toxic chemicals, adding to the process of inflammation caused by the trauma. The inflammatory process results in a coarse rubbery scar which creates a wall between the nerve stumps: they cannot reunite anymore. Surgery can help in these dramatic injuries by controlling the hemorrhage, clearing the field from debris, and stabilizing the vertebral fractures; however, it is not possible to suture the fibers end-to-end (they are often thinner than a hair). A first therapeutic achievement was the use of a potent anti-inflammatory drug (methyl-prednisolone) to mitigate the inflammatory reaction. More recently, a second advance has been the development of artificial gels that are placed in the gap and provide a scaffold for fibers to regenerate, drugs to be delivered and transplanted stem cells to differentiate and replace dead cells. We want to provide a third step forward by developing a surgical technique which will allow the placement of an artificial device around the lesion.

This device will create a kind of shelter where the reparative process will take place while the inflammation process rages outside. The device will provide a significant barrier against the cells, fibroblasts in particular, that will converge at the site of the lesion. Its action, however, is not that of a pure sealing (that will be impossible at the cellular level and that will be not totally desirable for the regenerating cord) but more a "deception"; fibroblasts attack the device in numbers, so very few will remain available to interfere with the regeneration process taking place inside. This approach may be technically demanding (it is not an easy surgery) and challenging from a biomaterial point of view (the device must be degradable and disappear after some time). However, it has proven to be effective in treating single peripheral nerve lesions where artificial devices, in the shape of conduits, are routinely used in the clinic. We want to translate this approach to the spinal cord, as if it was a giant single nerve. Our proposed approach may greatly enhance the probability of success for acute surgical treatment. It will easily integrate and extend the efficacy of many current treatments. It may likely open, in the future, new possibilities to revive the surgical approach to chronic lesions.

It has been esteemed that more than 6,000 New Jersey residents now live with traumatic spinal cord injury (nationally the number totals 200,000+ and about 300 of the estimated 11,000+ new spinal cord injury cases in the US every year are New Jersey residents). It is often outlined that direct medical costs are exorbitant. Indirect costs on victims and their families are harder to quantify, but place a significant burden on individuals, local and state resources. The toll in emotional costs and quality of life is incalculable (NJCSCR website).

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NEW JERSEY COMMISSION ON SPINAL CORD RESEARCH

CSCR18ERG007
Mohammed Abdul Muneer Peringady, Ph.D.
John F. Kennedy Medical Center
$200,000

Role of GDF10 in Promoting Axonal Regeneration and Functional Recovery after Spinal Cord Injury

We will develop a targeted gene transfer methodology against spinal cord injury by exploiting the neuronal growth-promoting potential of GDF10 in promoting axonal regeneration and functional recovery.

Spinal cord injury (SCI) occurs when there is damage from trauma, loss of normal blood supply, or a mass effect due to compression from tumor or infection. Unlike other parts of the body, the regenerative ability of the spinal cord is relatively poor. The inability of axons to regenerate after SCI is attributable to a combination of effects of the non-permissive extrinsic factors including myelin proteins and chondroitin sulfate proteoglycans (CSPGs), and cell-autonomous intrinsic factors including cAMP, RhoA, Krüppel-like factors, mammalian target of rapamycin (mTOR) and phosphatase and tensin homolog (PTEN). However, the factor(s) that may be triggered to promote the initiation of a molecular growth program and axonal sprouting in SCI are largely unknown.

In the present project, we propose to explore the possibility of developing a novel therapeutic approach to SCI by exploiting the neuronal growth-promoting potential of growth differentiation factor 10 (GDF10), a potential gene belongs to the transforming growth factor beta (TGF-ß) superfamily. GDF10 regulates several molecular signaling systems to induce a neuronal growth state. Our focus on GDF10 as a therapeutic target after SCI is based on the observation that GDF10 regulates major axonal regenerative cues including PTEN, phosphoinositide 3-kinase (PI3K) and suppressor of cytokine signaling 3 (SOCS3). Thus, we hypothesize that up-regulation of GDF10 will mitigate PTEN-mediated inhibition of axonal regeneration. We will also examine the specific effects of GDF10 on other major regulatory signaling cascades of axonal regeneration, the PI3K, SOCS3 and PTP pathways in vitro and in vivo. In order to up-regulate GDF10 in experimental animals, we will deliver GDF10 gene via lentivirus into the sensory-motor cortex and dorsal raphe nucleus areas of the brain, and evaluate the subsequent progress of axonal regeneration and functional recovery after SCI. Findings from this project will help to clarify the specific role of GDF10 in axonal regeneration and functional recovery after SCI and establish a basis for pursuing GDF10 as a therapeutic strategy for spinal cord injured patients.

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FELLOWSHIP RESEARCH GRANT RECIPIENTS:

CSCR18FEL010
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$60,000

Orthostatic Blood Pressure and Arterial Stiffness in Persons with SCI: The Effect of the Renin-Angiotensin-Aldosterone System

This investigation seeks to determine if increased reliance on the RAAS for orthostatic BP regulation contributes to differences in supine AS in individuals with SCI and age-matched controls.

In New Jersey, approximately 6,000 residents suffer from traumatic injuries or disease that damage the spinal cord. With advances in acute medical care, longevity has increased in persons with SCI; however, morbidity due to cardiovascular disease (CVD) occurs at an earlier age compared to the general population. Additionally, individuals with chronic SCI are at a heightened risk of CVD due, in part, to autonomic nervous system (ANS) dysfunction, physical inactivity and increased inflammatory processes. Arterial stiffness (AS) is recognized as an independent risk factor for CVD and, specifically, pulse wave velocity (PWV) has been proven to be a valid tool to predict and track structural arterial changes that reflect arteriosclerosis. Evidence has shown that persons with SCI have increased AS compared to uninjured able-bodied controls; however, possible contributors to this increase are not yet fully understood.

After a SCI, sympathetic control in the regions below the lesion level are severely disrupted; however, parasympathetic function is preserved. Due to the dissociation between the two systems, those with lesions above T6 experience low resting blood pressure (BP) and further decreases in BP when changing postures, which is called orthostatic hypotension (OH). Decreased plasma epinephrine and norepinephrine (NE) has been noted in individuals with cervical lesions when compared to individuals with thoracic injuries and controls. Additionally, lower levels of NE have been found to be associated with an increased incidence of OH in persons with SCI. As a consequence, individuals with high-level injuries have a heightened reliance on renin-angiotensin-aldosterone-system (RAAS) to maintain and stabilize BP. A mechanism for increased AS in the uninjured population is over activation of the RAAS. Angiotensin II (ANG II), a hormone produced through RAAS, creates vascular stiffening by reducing elastin, promoting collagen formation and increasing inflammation.

Therefore, the study aims are: 1) To investigate the influence of orthostatic change of BP and NE on the RAAS responses to orthostasis; and 2) To determine if increased reliance on the RAAS for orthostatic BP regulation contributes to differences in supine AS in individuals with SCI. The goal of this project is to lead to a greater understanding of the additional risk factors that contribute to CVD in order to help guide clinical treatment, which may ultimately result in preservation of cardiovascular health and longevity of New Jersey residents who have sustained a SCI.

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CSCR18FEL006
Sharareh Hashemi
New Jersey Institute of Technology
$60,000

Schwann Cells in Combination with GAG-mimetic Scaffolds for Spinal Cord repair

To develop a novel glycosaminoglycan (GAG) mimetic conduit to promote axonal growth in spinal cord injuries.

As a part of the central nervous system (CNS), the spinal cord transmits motor information to various parts of the body as well as receives sensory information from these parts. Spinal cord nerve tissue has a limited capacity to regenerate after spinal cord injury (SCI). In the United States, the annual incidence of SCI is 54 cases per million of the population annually, which is often because of a sports injury, motor vehicle accident, or even a fall. SCI is a devastating heterogeneous neurological condition with no effective treatment at the present time to restore the lost body function. After injury, the spinal nerve tissue undergoes a sequence of physiological changes followed by cascade of reactions at the affected site which eventually lead to a hostile environment for axon regeneration and so permanent disability. The extracellular matrix (ECM) is a 3D structural framework provides a suitable environment for cells in the central nervous system. The components of ECM have signaling and regulatory roles in the function of cells in the central nervous system to support a healing and regenerative response. Tissue engineered scaffolds mimicking the native extracellular matrix (ECM) may be a promising strategy to promote axonal growth. Among all different components of ECM, proteoglycans, which are proteins with covalently bound sulfated glycosaminoglycans (GAGs), have been shown to be an important component. Recent studies have shown chondroitin sulfate (CS) proteoglycans play an important role in axonal growth. They can either inhibit or promote axonal growth depending upon the degree and pattern of sulfation. GAGs have been shown to interact with and regulate growth factors, chemokines and cytokines. Recent work has shown that growth factor binding to GAGs is strictly controlled by the pattern and degree of sulfation. We have developed a GAG mimetic, sodium cellulose sulfate (NaCS), which can be tailored to have varying degree and pattern of sulfation similar to native GAGs, CS-C and CS-D, which have sulfates in the 6th carbon position and in both the 2nd and 6th carbon positions, respectively. Schwann cells (SCs) are of interest to be used in combination with this scaffold since they secrete neurotrophic factors stimulating neuron survival and extension of axons. This study proposes to evaluate the novel use of SCs in combination with a GAG-mimetic scaffolds for spinal cord repair.

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CSCR18FEL009
Marisa Jeffries
Rutgers University RBHS
$60,000

mTOR Signaling in Oligodendrocytes after SCI

The mTOR signaling pathway may play a critical role in preserving and repairing white matter after SCI, which would make it a potential therapeutic target for promoting functional recovery post-SCI.

Spinal cord injury (SCI) is a major burden that often requires substantial medical intervention and lifelong care, with an estimated 285,000 patients currently in the U.S. alone. In SCI, patients experience decreased quality of life and loss of function due to partial or complete paralysis, which is a result of damage to nerve cells, or neurons, in the spinal cord. However, this initial damage to neurons is not the only problem that contributes to SCI pathology: SCI also leads to loss of myelin, a specialized cell membrane that insulates the central nervous system (CNS) to enable efficient signaling and promotes neuronal health. Without the support of myelin, neurons are at risk for further degeneration, which in turn exacerbates functional loss after SCI. Because of this, finding methods to prevent this demyelination could limit functional loss after SCI. Interestingly, even if neurons can be stimulated to regenerate, functional recovery may be minimal without the presence of healthy myelin. Myelin repair, or remyelination, can occur after SCI, but this repair is often incomplete and may limit functional recovery for patients. In addition to finding methods to minimize demyelination, it is important to identify potential therapeutic targets that can promote remyelination to maximize functional recovery. Specifically, we need to understand how we can promote the survival of oligodendrocytes (OLs; the cells that make myelin), the production of new OLs, and the production of myelin after SCI. We have discovered that the mTOR signaling pathway is critical in maintaining healthy OLs and myelin in the CNS. Based on published and new preliminary data, I hypothesize that mTOR signaling promotes white matter sparing and repair after contusion SCI by reducing OL susceptibility to insult and enhancing OL and myelin production, making downstream effectors promising targets for promoting myelin repair and functional recovery after SCI. To address this hypothesis, I will determine how 1) mTOR affects demyelination and loss of function post-SCI, and 2) mTOR affects remyelination and functional recovery post-SCI. The results from completing this proposal will aid in determining whether the mTOR signaling pathway represents a potential novel target in OLs for limiting functional loss and promoting functional recovery after SCI.

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CSCR18FEL005
Christopher Rathnam
Rutgers University
$60,000

Fabrication of Biodegradable Peptide Nanoparticle Artificial Transcription Factor for the Treatment of Spinal Cord Injury

This project focuses on developing a highly efficient biodegradable nanoparticle that can regulate gene expression to treat spinal cord injury with a long-term goal to repair motor function.

The goal of this proposal is to develop a new technology that is called NanoScript for the treatment of spinal cord injury. NanoScript is a nanoparticle that can turn on or off genes in cells that can control what the cells do. By carefully designing the NanoScript platform it can be tailored to turn various cell types into neurons which are the function unit of the central nervous system. This platform will be optimized and tested in three different cell lines chosen based on their clinical relevance. This proposal outlines two different therapeutic avenues. The first involves transplantation of cells, after being converted to neurons by NanoScript, into the damaged spinal cord of rats to reconnect the damage spinal cord. The second involves directly delivering NanoScript into the spinal cord to convert the local cells that invade the injury site into neurons to reestablish the neural connection. This will further research on cell transplantation into the spinal cord and can potentially lead to a clinically relevant therapeutic option.

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SPINAL CORD TECHNIQUES TRAINING TRAVEL GRANT RECIPIENTS:

CSCR18TTT002 - $4,000
Sara A. McEwan
Rutgers University

According to the National Spinal Cord Injury Statistical Center, the incidence of spinal cord injury (SCI) in the United States is approximately 54 cases per million, with 17,500 new cases each year as of 2017, not including cases resulting in death at the scene of the accident. SCI can result in paralysis and degenerative neuronal disease, which is why understanding the molecular mechanisms and therapeutic approaches for SCI are of high relevance. For this reason, I developed a strong interest in studying traumatic neuronal injury and the resulting neurodegeneration.

Upon joining the Firestein laboratory, I contributed to a project involving the investigation of the role of cypin (cytosolic PSD-95 interactor), in traumatic brain injury (TBI) through the use of small molecule compounds. This project, conducted by a former graduate student, Dr. Przemyslaw Swiatkowski, involved the electrophysiological, survival, and behavioral effects of cypin modulation after traumatic brain injury. In brief, we found that activation of cypins activity leads to improved function, increased neuron survival, and improved neurobehavioral performance after TBI.

For my thesis research, I chose to translate this work into examining the role of cypin in spinal cord injury by altering its expression through overexpression and knockdown experiments. Cypin is a guanine deaminase that promotes dendritic branching and microtubule assembly. Our laboratory has published data supporting the idea that cypin plays a role in the recovery process after an in vitro glutamate-induced injury model of TBI. It is therefore of great value to assess the role of cypin after an in vitro culture and slice models of spinal cord injury. This project will directly investigate the neuroprotective potential of cypin by examining its contribution to SC neuronal survival, morphology, and electrophysiological function after glutamate-induced injury. I will test this hypothesis both in mixed spinal cord culture and organotypic spinal cord slice models of cypin knockdown or overexpression, examining the effect on both the structure and function of spinal cord neurons after injury.

This project will complement, but not replicate an ongoing NJCSCR-funded project in our lab. Dr. Firestein was awarded a grant from the NJCSCR in collaboration with Dr. Stella Elkabes (New Jersey Medical School-Rutgers: Newark) based on the hypothesis that activating the enzymatic activity of cypin with small molecules used in our lab TBI studies will improve motor and sensory neuron survival, electrophysiological function, and behavioral performance following SCI. This project is based on the hypothesis that activation of cypin will result in increased production of uric acid, a neuroprotective compound, which will ultimately result in recovery of function after in vitro and in vivo spinal cord injury. While I have begun training in cell and slice culture in addition to electrophysiology, I lack the knowledge and skills required to successfully perform SCI in vivo. I believe that granting me this training award will allow me to take the Spinal Cord Injury Research Methods Workshop at the W. M. Keck Center for Collaborative Neuroscience at Rutgers University and translate my acquired knowledge towards translating the results from my in vitro studies into an in vivo SCI model and enhancing knowledge and skills for my thesis work and my goal of becoming an SCI researcher.

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NEW JERSEY COMMISSION ON SPINAL CORD RESEARCH

CSCR18TTT003 - $4,000
Anton Omelchenko
Rutgers University

My training goals include to learn the molecular techniques and injury model approaches utilized to research and discover novel molecular targets for the development of therapeutics that may ameliorate or prevent further cell damage after spinal cord injury. I plan to learn and understand the steps involved in the drug development pipeline, to be able to make significant contributions to therapeutic discovery. I would like to gain adequate understanding in experimental design to effectively investigate the molecular mechanisms behind secondary spinal cord injury in order to curtail preventable cell damage and to foster a cellular environment which promotes axonal regeneration.

I plan to attend the spinal cord injury techniques course to learn and better understand the injury model approaches utilized to develop therapeutics for spinal cord injury. As my current work focuses on discovering potential pharmacological agents to ameliorate the secondary damage associated with spinal cord injury and traumatic brain injury in vitro, I would like to continue to test potential therapeutics utilizing an in vivo spinal cord injury model. While discovering possible molecular targets and potential therapeutics in vitro is important and necessary, extensive testing must be performed with in vivo animal models of any pathological condition or disease before any potential therapeutic progresses further down the drug development pipeline. I expect that taking the spinal cord injury techniques course will significantly expand my current set of scientific skills, and provide me with the opportunity to further investigate the neuroprotective potential of pharmacological agents that I find efficacious in my in vitro studies.

As a student in the Firestein laboratory, my work has primarily focused on the development of a microfabricated device that can be used to model Traumatic Brain Injury (TBI) in vitro and to screen pharmacological treatments for injury in a high-throughput manner. As mitochondrial dysfunction has been previously implicated in the excitotoxicity and cellular damage that occurs during TBI secondary injury, we hypothesized that targeting mitochondrial disfunction after stretch/strain injury (diffuse axonal injury) will promote axonal survival and diminish secondary damage following trauma. The device is constructed using polydimethylsiloxane (PDMS), a silicon-based polymer, and consists of two compartments connected by microfluidic channels. Two separate hippocampal organotypic rat brain slices are cultured within the two compartments, and the two slices create axonal connections through the microfluidic channels. In order to model TBI, uniaxial strain is applied beneath the axons spanning through the microchannels, and mitochondrial function is examined in the axons of neurons with fluorescence microscopy and label-free optical scatter imaging. Potential therapeutics are applied at different time points in the time-course of injury, and axonal viability and mitochondrial dynamics are subsequently measured. Our current findings suggest that application of a low-strain injury induces significant mitochondrial fragmentation (fission), and that the severity of fragmentation may play a role in axonal viability outcome. Additionally, our findings suggest that mitochondrial localization may play a role in axonal bead formation and that directly inhibiting mitochondrial fission may lead to significantly greater axonal beading and attenuate axonal viability following stretch/strain injury. Lastly, we are currently working on expanding the capabilities of our device to house several organotypic slice pairs from different animals in order to expand the throughput capacity of our system. Overall, my work on this project has greatly shaped my ongoing interest in the discovery of novel targets to aid in the development of therapeutics aimed to treat and prevent secondary damage following neural trauma.

In the future, I would like to pursue an academic position as a Principal Investigator in a research university setting. I plan to continue to conduct research on novel molecular targets for therapeutics aimed to treat and prevent secondary injury following spinal cord injury and traumatic brain injury, and I believe that taking the techniques training course will provide me with the skills and opportunities that will significantly facilitate my ability to achieve my goals.

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