X-GRANTS
ROUND 2

September 28, 2020

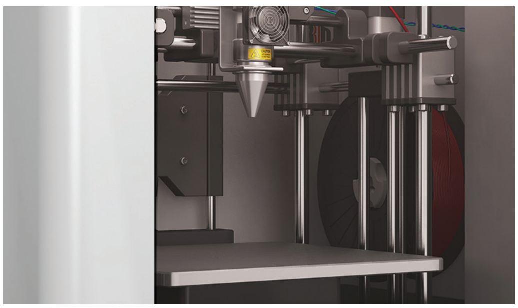
PRESIDENT'S EXCELLENCE FUND SYMPOSIUM

X-GRANTS

An interdisciplinary research program that is part of the ten-year, $100 million President's Excellence Fund. The first year $7 million was awarded to fund eight projects to faculty-researchers to stimulate and support innovative interdisciplinary research. Rounds 2 and 3 each awarded $7 million in funding to Texas A&M researchers. This program is open to all faculty, researchers, and staff at Texas A&M University, Texas A&M University-Galveston, Texas A&M University-Qatar, TEES, TEEX, AgriLife Research, AgriLife Extension, and TTI.

3D PRINTED BIO-ARTIFICIAL PANCREAS

Leader: **Akhilesh K. Gaharwar**
Co-Leaders: **Abhishek Jain, Yuxiang Sun**
Members: **Daniel L. Alge, Kayla J. Bayless, Robert Alaniz, Travis Hein**



Type 1 diabetes (T1D) affects more than half a million children globally, with a 7 percent mortality rate within 25 years of diagnosis. In T1D, the body does not produce insulin because pancreatic beta cells, functioning as insulin-factories, are attacked by the immune system. The objective of this X-grant is to design a 3D printed bio-artificial pancreas with a vascularized network to protect encapsulated islets. Upon completion of this project, we expect that we would have demonstrated *in vivo* potential of 3D printed scaffolds to stimulate rapid vascularization in a small animal model and survival of encapsulated islets for a prolonged duration with sustained insulin production. This study will build a strong foundation for future large animal studies.

A BRAIN-INSPIRED APPROACH TO RAPID AND ENERGY EFFICIENT INFORMATION PROCESSING: AI ON THE FLY

Leader: **Sarbajit Banerjee**
Co-Leaders: **Patrick J. Shamberger, Richard Williams**
Members: **Raymundo Arroyave, Perla B. Balbuena, James D. Batteas, Lei Fang, Peng Li, Bani K. Mallick, Samuel M Palermo, George Pharr, Xiaofeng Qian, Kelvin Xie**

The electronics revolution of the past five decades has been pivotal to improving the global quality of life. However, this revolution has been powered primarily by exponential improvements in silicon integrated circuits with time (known as Moore's scaling), which has now run up against some seemingly intractable roadblocks. The human brain serves as a powerful exemplar of processing complex information with minimal energy dissipation. The energy efficiency of the brain stems from its ability to use an adaptive approach, responsive to "events" triggered by external stimuli, wherein multiple internal states are accessed and retained in a manner reflective of past conditioning. Unlike binary von Neumann architectures, neural elements use distributed, dynamically evolving, and interacting weights stored across a dense, highly interconnected network. Realizing solid-state analogs of neural circuitry, in what are known as 'neuromorphic' materials, holds promise for enabling a new energy-efficient computing paradigm.

To emulate neurons and synapses, the electrical conductance of materials must be switched across orders of magnitude in an energy-efficient manner, thereby defining physical analogues of action potentials, i.e., neural spikes. Additionally, these spikes must be precisely correlated across space and time with tunable retention of internal states. Furthermore, individual devices must be assembled within an interacting network that collectively provides emergent learning, memory, and processing functions. We propose to develop novel dynamical materials with nonlinear conductance switching emulative of neural elements and to build altogether new circuit elements from such materials that can perform tasks that would require hundreds to thousands of transistors. A major advantage will be the immediate updating of the system in response to external events, thereby realizing the full promise of artificial intelligence to learn and respond in real-time.

BIOLOGY HIDDEN IN RNA STRUCTURE AND MODIFICATIONS

Leader: **Xiuren Zhang**
Co-Leaders: **Jorge A. Cruz-Reyes, Jing Cai, Jonathan Sczepanski, Jun-Yuan Ji, Junjie Zhang, Lanying Zeng, Kristin Patrick**

In the central dogma, RNA is thought to be only a messenger bridge between DNA and proteins. However, RNA is now known to influence many aspects of life through activities that are attributable to its secondary structure (RSS). In fact, RSS contains a new set of information code that is interpreted and processed by specialized proteins. Moreover, some small molecules are attached to RNA species to alter their properties and correspondingly their functions in biological processes.

The large SWItch/Sucrose Non-Fermentable (SWI/SNF) chromatin-remodeling complexes typically release DNA from its bound protein partners and promote RNA production. A recent groundbreaking discovery revealed that the complexes could directly bind to a subset of RNA, remodel its secondary structure, and turn off downstream RNA processing in the model plant Arabidopsis. In this setting, an interdisciplinary team is assembled to systematically study how the SWI/SNF complexes remodel different species of RNA at the genome-wide scale in several representative organisms; and whether and how the RSS remodeling coordinates with RNA editing/modifications to alter the physiological paths.

The team will address this exciting project using arrays of modern approaches including molecular genetics, high throughput sequencing, computational analysis, single-molecule imaging *in vivo*, cryo-electron microscopy *in vitro*, and synthetic chemistry. Once completed, the study will not only fundamentally change our views on transmission and decoding of genetic information, but also provide new ideas and strategies to manipulate RNA structures and modifications to improve agricultural production and pharmaceutical therapies for treatment of human diseases.

DIGITAL TWIN CITY FOR AGE-FRIENDLY COMMUNITIES: CROWD-BIOSENSING OF ENVIRONMENTAL DISTRESS FOR OLDER ADULTS

Leader: **Changbum R. Ahn**
Co-Leaders: **Theodora Chaspari, Youngjib Ham, Chanam Lee**
Members: **Michael P. Manser, Preeti Zanwar, Shuman Tan**

Population aging is a global concern, and it demands smarter and more connected cities for independent mobility and healthy aging of older adults. However, traditional urban planning and design practices that target the "average person" have failed to meet the special needs of older adults experiencing multiple physiological and psychological declines associated with various stages of aging. To address this grand challenge, this project aims to construct a digital twin city (DTC) model with bio-signals (i.e., physiological sensing data from older adults' wearable devices) and photos (i.e., visual sensing data of infrastructure defects and neighborhood disorder from smartphones); this model will serve as a digital replica of the city that shows older adults' collective distress—detected from bio-signals—and associated environmental conditions, thereby allowing us to continuously identify where, why, and to what extent older adults experience distress in their daily routine. The DTC model will be leveraged to design and simulate stress-aware interventions to promote older adults' mobility and healthy behaviors (e.g., identify the least stressful first-and-last mile trip path to access transit).

ENGINEERING BRAIN HEALTH

Leader: **Stephen Maren**
Co-Leaders: **Sung Park, William Griffith**
Members: **Annmarie MacNamara, Karienn Montgomery, Justin Moscarello, Jun Wang, Byung-Jun Yoon**

Psychiatric and neurological disorders, including post-traumatic stress disorder (PTSD), chronic pain, and age-related neurodegeneration, are devastating health conditions that affect a large portion of the population. Unfortunately, successful treatment of these disorders has been hampered by the absence of neurological interventions that can precisely target the parts of the nervous system that are affected by disease. However, the past decade has witnessed major technological advances in neuroscience, genetics, and engineering that pave the way for new and specific treatment approaches. Here we take a state-of-the-science approach to translate our understanding of neural circuits underlying disease into a cutting-edge, implantable, and wireless neuroprosthetic “pacemaker” that will restore normal function in dysregulated brain circuits. This wireless, closed-loop optogenetic stimulator (CLOPS) will detect aberrant hyperactivity in animal models of psychiatric disorders and normalize this activity with targeted activation specific brain circuits and cells. This interdisciplinary project has the potential to yield a game-changing advance over current therapeutic approaches for psychiatric and neurological disease, because current therapies neither directly interface with brain tissue nor do they dynamically adapt the therapeutic intervention to an individual’s brain activity.

NEW QUANTUM MATERIALS FOR NEXT-GENERATION QUANTUM SYSTEMS

Leader: **Dong Son**
Members: **Alexey Akimov, Sarbajit Banerjee, Alexey A. Belyanin, Xiaofeng Qian, Matthew T. Sheldon**

In this proposal, we aim to develop new material systems based on the chemically prepared colloidal quantum dot (CQD) system as a practical platform for fabricating scalable solid-state qubits for quantum information processing applications. Quantum computation (and simulation) is one of the new tools that enable significant speedup in solving the problems complex for traditional digital computers. At the core of this problem is the quantum entanglement and algorithms to perform the operations using long-lived coherence to accelerate computation process. To realize such quantum information processing, preparation of the stable and controllable superposition of the quantum state created from the coupled qubits in a scalable manner is necessary. Recently, lithographically patterned superconducting qubits made much progress in building prototype quantum computing hardware. Despite such progress, continued efforts are being made to develop other platforms for constructing qubits to overcome the shortcomings of currently explored quantum systems, such as limited scalability and difficulty of fabrication, while harnessing the superior performance of more traditional systems such as cold ions or atoms in optical traps. To this end, the team aims to explore chemically prepared CQD systems carrying quantum information with very high ensemble uniformity of the structure and property as the new building blocks of the qubits that are compatible with scalable manufacturing.

PROJECT X-CEL: ELIMINATING BIAS IN SCHOOL DISCIPLINE THROUGH TEACHER TRAINING

Leader: **Jamilia J. Blake**
Co-Leader: **Phia S. Salter**
Members: **Chayla H Davison, Chanda D. Elbert, Marlon C. James, Shweta Kailani, Wen Luo, Patrick Goldsmith, Nathaniel D. Poling, Zachary F. Price, Srividya Ramasubramanian, Noelle W. Sweany**

School discipline remains a topic of national concern, and educational leaders are facing increasing pressure to adopt new approaches to reduce school disciplinary infractions and disparities. Whereas a number of school-based discipline practices exist, research shows that these approaches are not culturally responsive and do not effectively reduce racial disparities in school discipline. Redressing these trends is critical given that research has linked discipline disparities with test score gaps, disparities in ACT and SAT incomes, and even with variances in graduation rates. To address racial disparities in school discipline, Project X-CEL, led by Dr. Jamilia Blake, will develop and evaluate the effectiveness of a teacher professional development training that will reduce gendered racial bias in school discipline outcomes.

REMOVING MENTAL HEALTH STIGMA IN HIGHER EDUCATION THROUGH REMOTE MONITORING AND TELEHEALTH COUNSELING

Leader: **Farzan Sasangohar**
Co-Leaders: **Mary A. Covey, Bita A. Kash, Israel Liberzon, Carly E. McCord, Anthony McDonald, Ranjana Mehta**
Members: **Arjun Rao, Cason D Schmit**

Research has consistently shown a rapid growth in the number and severity of psychological problems among university students. Recently, the use of remote health monitoring and communication technologies has shown promise in improving quality of care. In particular, the prevalence of sensor-enabled devices such as smartphones have the potential to increase access to and continuity of care by extending treatment beyond scheduled office visits. Our interdisciplinary team will address this research gap by utilizing a mixed methods pilot study utilizing facilitated dialogues on mental health, remote monitoring using a novel wearable tool, and telehealth counseling sessions. Our goal is to establish a complex sociotechnical infrastructure that uses proactive counseling as well as ubiquitous computing capabilities to detect changes in mental state. This will allow us to interact with students to triage or provide support, as well as to facilitate data collection and monitoring between students and therapists. The continuous monitoring of students is expected to contribute to decreased depression and anxiety levels and improve the quality of life among university students and facilitate evidence-based diagnostic or treatment decisions based on real-time data and have implications in the design of clinical decision-support systems for mental health therapists.

This proposed research represents a substantive departure from the *status quo* by enabling real-time monitoring and documentation of mental health and student-clinician interaction and care. The system will use mobile sensors to monitor key mental state change indicators, identify mental state changes using personalized machine learning algorithms, which will trigger counseling communication events.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