Columbia University Fortifies Research Collaborations with Distinguished Funding Competition

RISE competition identifies six teams to receive funding for innovative research collaborations.

NEW YORK, July 21, 2017—Columbia University Office of the Executive Vice President for Research announced today the names of six teams receiving funding through **Research Initiatives in Science and Engineering** (RISE), one of the largest internal research grant competitions within the University. The annual award provides funds for up to six interdisciplinary faculty teams from the basic sciences, engineering, and/or medicine to pursue blossoming and extremely creative research projects. Each team's award is worth $80,000 per year for up to two years.

The RISE competition was created in 2004 to provide Columbia faculty and research scientists with the initial funding necessary to explore paradigm-shifting and high-risk ideas. Amidst federal budget cuts for the sciences, researchers are increasingly challenged to provide more conclusive initial proofs of concept to demonstrate viability, even though they lack funding to complete such preliminary work. In this competition, Columbia follows the National Institutes of Health's definition of high-risk research as having "an inherent high degree of uncertainty, and the capability to produce a major impact on important problems."

"RISE serves two fundamental purposes: Firstly, it seeds imaginative and daring interdisciplinary research collaborations," says **G. Michael Purdy**, Executive Vice President for Research, and Professor of Earth and Environmental Sciences. "Secondly, it strengthens these projects chances of receiving future federal funding in a mutable climate. RISE will empower these six new teams, just as it has done for the 61 previous awarded teams. RISE's investment can be quantified–funded projects have received back 600% of the original investment in follow-on funding from the government and foundations, which testifies to the distinction of our researchers and the great utility of seed funding at Columbia. With the impending cuts to federal discretionary spending, seed funding programs such as RISE have never been more important."

The 2017 competition accepted 29 Round 1 applications, thereafter inviting 10 full proposals into Round 2. Between six and nine reviewers were assigned to each Round 2 proposal in order to evaluate the interdisciplinary quality, potential impact, and innovation of each project. 94 reviewers—tenured or tenure-track faculty or research scientists within the University—participated in selecting this year's awarded teams.

"It is never easy to select only five or six projects from so many extraordinary proposals," says **Victoria Hamilton**, Executive Director of Research Initiatives, and administrator of RISE. "This year alone, 94 reviewers generously lent expertise to select the high-risk, high-reward proposals that RISE seeks to seed. Some of these six projects—just like some of the previously awarded projects—may not result in the substantial discovery and impacts that they targeted, but this is the hallmark of risky research. We are excited by each of the teams and their proposed challenges, and eagerly await the inevitably remarkable discoveries that these investigations will make over the coming years."

2017 RISE AWARDEES

Integrating Information Sampling and Decision Making Through Large Scale Testing of Human Information Seeking Behavior
Jacqueline Gottlieb, Associate Professor, Department of Neuroscience
Michael Woodford, John Bates Clark Professor of Political Economy, Department of Economics

Understanding information sampling decisions—our ability to seek information from specific sources at specific times—is crucial for describing phenomena of central interest in economics, neuroscience, and psychology. However, our field has scant empirical evidence that characterizes such decisions and can constrain formal theories. The experiments we propose are motivated by preliminary data we obtained indicating that human information sampling policies show marked individual variation and contradict the predictions of normative models. We propose to extend these results by developing novel APPs that are downloadable on mobile devices, and allow collection of much larger data sets than is possible with standard methods (20,000 participants or more). In parallel, we will extend prominent economic theories of information sampling in ways that are consistent with the empirical data. Together, our efforts will (1) provide empirical answers to key questions regarding information sampling policies; (2) allow significant extension of normative theories of decision making to take account of informational constraints and the strategies that individuals use to overcome these constraints; and (3) establish a robust behavioral testing platform that can be extended in the future to gather other types of "big data" on human behavior.

APTAPAINT: Towards Single-Molecule Glycan Sequencing

Henry Hess, Professor, Department of Biomedical Engineering
Milan Stojanovic, Associate Professor of Medical Sciences (in Medicine), Departments of Medicine and Biomedical Engineering
Sergei Rudchenko, Adjunct Assistant Professor, Department of Medicine

We pursue a super-resolution microscopy approach named APTAPAINT that maps substructures on individual sugar molecules using engineered oligonucleotide-based receptors (aptamers). APTAPAINT will be used in a wide array of applications, from precise assessment of binding kinetics, to epitope mapping, structure reconstruction and heterogeneity studies. As a result of our experiments and the introduction of advanced imaging and signal processing approaches, we will enable commonly available and low-cost microscopes as broadly applicable tools in studies of complex sugars. We will additionally pursue the potentially transformational ability to sequence individual oligosaccharide molecules.

A Novel Spectrometer for Discovering Signals from the Beginning of the Universe

Bradley Johnson, Assistant Professor, Department of Physics
Harish Krishnaswamy, Associate Professor, Department of Electrical Engineering

The cosmic microwave background (CMB) is a bath of photons that fills the entire Universe, and carries critical information about how the Universe began. CMB observations to date have helped reveal that the Universe is 13.8 billion years old, space-time is flat, and the energy content of the Universe is primarily composed of mysterious dark matter and dark energy. The field of CMB research is now searching for exciting and extremely faint new signals embedded in the CMB that appear today as spectral distortions. In particular, a recombination line signal should have been produced when hydrogen and helium nuclei captured electrons when the Universe existed as a structure-less primordial plasma. These emission lines must exist if our understanding of the early Universe is correct, so a recombination line experiment will serve as a unique and powerful test of the current cosmological model. Further, a precise characterization of this spectrum will yield information about the relative abundances of hydrogen and helium in the Universe when it was approximately 380,000 years old, because these two nuclei produce unique features in the spectrum. One feature-rich section of the recombination line spectrum lies between 3.5 and 8.5 GHz, and our ultimate goal is to be the first to discover the recombination line signal by making spectroscopic measurements in this spectral band. The anticipated signal is extremely faint and therefore challenging to detect. Forecast calculations show that an array of thousands of cryogenically-cooled antenna systems will ultimately be needed to detect the cosmological signal. Therefore, a piecemeal approach that starts with the rigorous study of a single prototype antenna is appropriate. With RISE support, we will leverage exciting and ongoing R&D work in the field of silicon RF electronics for commercial wireless communication applications and develop a scalable spectrometer array element that will serve as a stepping-stone to a large array in the future.

Predicting Volcanic Eruptions Using Real-time 4D+ Microscopy of Bubble Interactions in a Solid-Liquid Mush
Einat Lev, Lamont Assistant Research Professor, Division of Seismology, Geology and Tectonophysics, Lamont-Doherty Earth Observatory
Elizabeth Hillman, Professor, Departments of Biomedical Engineering and Radiology

Magma, the driver of volcanic eruptions, is a three-phase mixture composed of liquid melt, solid crystals, and gas bubbles. The interaction between these three components determines the style of eruption: a violent explosion, a moderately energetic lava fountain, or a quietly oozing flow. Scientists studying volcanoes have developed theories to describe how particles or bubbles move within a viscous liquid, yet models for the behavior of all three phases together are still lacking. Lab experiments using three-phase mixtures have so far been limited in their ability to directly observe these interactions–experiments have observed flow from the outside of the flow chamber, flows have been limited to only narrow, two-dimensional domains, or three-dimensional images have been made only after flow and interactions have ceased. We will be using a novel microscopy technique (SCAPE) to image, for the first time, the interaction of particles and bubbles suspended in a viscous liquid, in three dimensions and in real time. Our observations will provide constraints to models of three-phase flow and insight into magma dynamics and volcanic eruptions.

Brain Functional Imaging with Simultaneous fMRI and Doppler Ultrasound
Qolamreza Razlighi, Assistant Professor of Neuroimaging, Department of Neurology and the Taub Institute for Research on Alzheimer's Disease and the Aging Brain
Elisa Konofagou, Robert and Margaret Hariri Professor, Departments of Biomedical Engineering and Radiology
Ken Shepard, Lau Family Professor, Departments of Electrical Engineering and Biomedical Engineering

We propose a novel, non-invasive, whole-brain, and *in vivo* functional imaging method, which has the potential to provide a significantly more direct measurement of brain neuronal activity than is currently possible with BOLD fMRI alone. This method combines traditional fMRI with simultaneous real-time 4D ultrafast ultrasound Doppler imaging. The acquired imaging data will go through a set of post-processing reconstructions to generate brain functional images that measure CMRO2 at resolutions better than that achieved in BOLD signal. This functional imaging method is expected to have widespread impact on neuroscience research, providing a significant step forward in investigating neurodegenerative diseases such as Alzheimer.

Visualizing Ion Transport in Battery Electrolyte by Stimulated Raman Scattering Microscopy
Yuan Yang, Assistant Professor, Department of Applied Physics and Applied Mathematics
Wei Min, Associate Professor, Department of Chemistry

High-performance rechargeable batteries are indispensable to a broad range of applications, including electric vehicles and grid-level energy storage. Transport of ions in battery electrolyte and their insertion into solid electrodes are critical to battery performance. For example, inhomogeneity of ion flux in the electrolyte can deplete ions locally, which not only reduces energy/power density, but also deteriorates cycling life. Therefore, visualizing and quantifying ion transport in the electrolyte and at the solid-liquid interface will not only provide better understanding of battery processes, but also help design better electrolytes and electrodes to enhance battery performance and safety. Here we propose to use the emerging Stimulated

Raman Scattering (SRS) microscopy to realize such 3D imaging of ion transport in the battery electrolyte. SRS microscopy is label-free, and its dual-beam configuration employs the stimulated emission amplification, gaining 100 million times higher sensitivity than the common spontaneous Raman microscopy, which enables fast imaging at second level to resolve the transport dynamics of battery electrolyte. Such studies will deepen our understanding of battery reactions and guide further development of batteries with high performance

PROGRAMMATIC IMPACT

"My new project with **Brad Johnson** will develop a novel technology that will yield great insights into how the universe was created, by detecting minute cosmic distortions due to the recombination of hydrogen and helium in the early universe," says **Harish Krishnaswamy**, Associate Professor in the Department of Electrical Engineering, and 2017 RISE awardee. "Detecting these extremely weak signals requires building a radio receiver that can essentially find a needle in a haystack, requiring thousands of highly-sensitive antennas that can operate in the presence of extremely large interference signals. We believe that utilizing these emerging technologies from the telecommunications field can provide compelling insights into the history of the cosmos. While too wild for conventional federal funding, we believe that RISE program will better position us at launching this instrument into space, and will open up new opportunities for reimagining cosmic history and evolution."

RISE not only awards critical seed funding for risky and interdisciplinary collaborations; once the funding has ceased, it tracks how the seed funding contributes to the researchers' abilities to obtain subsequent sponsorship from government agencies and private foundations.

"It is critical for research institutions to provide internal funding in support of interdisciplinary research, especially as we see external funding budgets wax and wane," says **Christine Denny**, Assistant Professor in the Department of Psychiatry, and 2016 RISE Awardee. "For my project with **Michal Lipson**, we are developing a novel technology for both visualizing and manipulating memory traces in the entire mouse brain while not disrupting surrounding tissue – this could have a great influence on future studies in neurology and psychiatry, but federal funders would not sponsor this research without a proof of concept. RISE has given us the time and funds necessary to develop this proof of concept, and soon we will put it to the test. Had we not received RISE sponsorship, this investigation may never have happened."

Since 2004, RISE has awarded $9.22 million to 67 projects. These 67 teams later secured more than $55.4 million from governments and private foundations: a 600% return on Columbia's initial investment. These projects have additionally garnered more than 130 peer-reviewed publications and educated more than 130 postdoctoral scholars and graduate, undergraduate, and high school students. A complete list of **RISE-funded researchers** is available online.

Nominations for the 2018 competition will run from September to early-October 2017, with five to six awarded teams announced by spring 2018.

For interview requests and additional information, or to partially- or fully-fund a new RISE project, contact Marley Bauce (**marley.bauce@columbia.edu**; 212-854-7836).

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About the Office of the Executive Vice President for Research

COLUMBIA UNIVERSITY
Research Initiatives in Science & Engineering
Office of the Executive Vice President for Research

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