Project Title

Swallowable Capsules for Precision Probiotics and Future Gut Health Monitoring

Principal Investigators

Name	Department	College
Benjamin S. Terry (PI)	Mechanical Engineering	Engineering
John Chaston	Plant & Wildlife Sciences	Life Sciences
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Track

Track one

Abstract

The epidemic of autoimmune diseases, such as multiple sclerosis, rheumatoid arthritis, and inflammatory bowel disease, affecting nearly a billion individuals worldwide, may be linked to the gut microbiome's composition and function. This proposal outlines a pioneering approach to personalize gut health interventions by developing and refining a non-invasive, swallowable capsule designed for *in situ*, real-time microbiome monitoring. Focused on the cecum, a critical but underexplored site in microbiome research, our immediate objective is to demonstrate the feasibility of directly measuring real-time microbial dynamics *in situ*, overcoming limitations of current methodologies that rely on endpoint analyses. Our approach promises to explain the microbiome's response to probiotic interventions and inform the development of precision nutritional strategies and treatments. This work could revolutionize our understanding and management of microbiome-related diseases by offering unprecedented real-time insights into microbial ecology within the host environment.

Summary of Plans for External Funding

Building upon preliminary efforts, this work aims to establish a foundation for revising and advancing a previously submitted and unapproved R01 proposal and for submitting a new R15 proposal. To this end, our team will use results from this IDR study as preliminary data for two external grant proposals that will be submitted during the award period as follows:

- NIH National Institute of Diabetes and Digestive and Kidney Diseases R01. This funding mechanism has no direct cost limitation; however, we anticipate submitting a 5-year project totaling ~$3M in direct costs.
- NIH National Institute of Diabetes and Digestive and Kidney Diseases R15. This funding mechanism has a direct cost limitation of $300k total over 3 years. We anticipate submitting a grant proposal commensurate with these limits.

Project Narrative

I. Disease and the need for personalized, precision gut microbiome engineering.

Epidemic levels of autoimmune diseases like multiple sclerosis, rheumatoid arthritis, and inflammatory bowel disease impact nearly a billion people globally and are often linked to gut microbiome imbalances and intestinal barrier dysfunctions[1–3]. The gut microbiota's composition influences various health aspects, from drug metabolism and obesity to neurodevelopmental disorders, necessitating personalized treatment strategies[4–6]. The complexity of the gastrointestinal (GI) microbiome, influenced by individual genetics and environmental factors like diet and antibiotics, underscores the human body as a metabolic-regulatory 'super-organism'[7]. Targeting the microbiome in human health and disease – directly through probiotics or indirectly through dietary prebiotics – holds vast potential[6] that remains untapped because fundamental characteristics of the hypothesized therapeutics such as dosage, frequency, and duration of impact, remain completely unknown. A major reason that these questions have been poorly investigated is because virtually all microbiome studies focus on an endpoint measure: the quantity of microorganisms in a fecal or, rarely, a biopsy sample. Conversely, methods that reveal microbiome dynamics *in situ* can revolutionize prebiotic and probiotic development by revealing the impacts of microbiome-based therapeutics at the location where the microorganisms are acting[8–11]. This proposal articulates the first steps to developing such a tool.

Our long-term goal is to enable extended, non-obstructive, *in situ*, real-time monitoring of the colon microbiome by creating a non-invasive, swallowable capsule that autonomously attaches sensors to the cecum wall (**Fig. 1**). The short-term steps toward our goal are to show the feasibility of direct measurement of cecal microbiome activities and to refine a swallowable capsule to enable such measurements. Specifically, in this proposal, we will: 1) Evaluate the real-time response of porcine colon pH to probiotics using the BravoTM pH sensor, initially through surgical implantation to refine usage methods; 2) Design and validate *in vitro* a swallowable capsule for implanting a sensor in the cecum. After the work in this proposal, the next short-term step will be to revise a rejected R01 proposal that focuses on deploying a swallowable capsule to non-surgeried animals and defining host animal responses to microbiome-based interventions. The capsule will contain a sensor whose readouts will define dosage amounts and intervals that affect microbiome-based therapeutic changes on a host. Reviewers of our previous R01 proposal wanted more preliminary evidence showing that we could measure these changes in a host, and in this IDR we propose to do that. This approach has the potential to revolutionize the development of microbiome-based therapeutics by defining the basic ecology of such interventions in real-time and *in situ* and will lay the groundwork for future development of remote sensors that target specific microbiome functions to address and manage human health and disease through diet-based therapies and personalized nutrition.

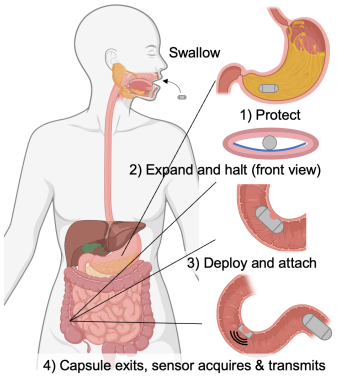

Fig. 1. Section view of the pH sensor-deployment functions of the proposed colon capsule.

II. Non-invasive capsules for in-situ, real-time monitoring of the colon microbiome.

Two unique aspects of our previously developed capsule are: 1) It autonomously and non-invasively deploys a non-obstructing, long-term sensor to the lining of the small intestine (SI)[16–18]; and 2) It acts as a "capabilities multiplier" for existing in-vivo sensing systems, enabling them, with minor modification, to acquire long-term, real-time data in the SI[16,17,19,20]. For example, the Medtronic Bravo™ system (**Table 1.**) was designed to evaluate gastroesophageal reflux disease, yet in this work, we propose to slightly modify the Bravo™ sensor to characterize dynamic proximal colon pH response to probiotic dosage via real-time *in-situ* monitoring.

Table 1. Commercial and research GI real-time sensor technology.

Readout	Technology
pH	Medtronic, Inc.[12]
Gut gas (CO_2, H_2, O_2)	RMIT research[13]
Status of various analytes (eukaryotic, epithelial, or PBMC cells)	Progenity, Inc.[14]
Heme-sensitive sensors for GI bleeding	MIT research[15]

We hypothesize that probiotics affect colon pH and that their effect can be measured in implanted, remote, autonomous, modified Bravo™ sensors in the colon. If so, our swallowable capsule platform with a modified Bravo™ could be utilized in research and clinical settings to non-invasively and accurately measure pH changes in the cecum in response to therapy and diet at a previously unavailable precision level. Additionally, this approach could justify development of other sensors with different readouts.

III. Previous work on long-term work, autonomous SI tissue attachment.

We have developed a swallowable capsule capable of deploying an autonomous sensor to the SI wall where the sensor attaches for up to 13 days[16–21]. We have omitted the details of how this works in the interest of space but emphasize that our peer-reviewed publications demonstrate the feasibility of capsule use[16–21].

IV. Aim 1: Characterize the real-time dynamic response of porcine cecum pH to probiotics.

With our capsule capable of delivering to the human GI wall, our next objective is to demonstrate the ability of a capsule payload to monitor the microbiome's major activity: short-chain fatty acid (SCFA) production. We plan to use commercial battery-powered pH sensors, adapted for integration with our capsule, to record cecum pH changes in response to probiotic and prebiotic interventions. Initially these sensors will be precisely placed in the cecum through surgery, eliminating location variability. Successful detection of microbiome alterations through this surgical method will provide essential preliminary data. This preliminary data will support our revised R01 proposal to use swallowable capsules' positioning for similar measurements in non-operated animals, paving the way for human application.

Hypothesis: Microbiome-based challenges to a pig that lower its gut pH can be detected by a surgically-implanted sensor[22]. *We hypothesize that a colon-implanted pH sensor can detect pH changes caused by probiotics that raise fecal butyrate levels (butyrate is a key SCFA).*

Approach. We will surgically implant a non-obstructing, autonomous, remote-sensing pH sensor into pigs. After the pigs recover from surgery they will be challenged with a sham treatment (control group) or with a series of probiotic and prebiotic formulations and dosages (treatment group) while the colon pH is monitored continuously in real time every 6 seconds for 14 days. Pig experiments are expensive, so the major aim of the IDR is to perform these monitoring experiments to track the change in treatment versus control group pig pH under this administration scheme. Additionally, we will analyze daily fecal samples for microbial and metabolomic compositions to compare fecal pH dynamics with real-time colon pH changes, as a baseline since these are the standard in animal microbiome studies.

1. Preparation of the pH monitoring capsule: Currently no commercial device exists to measure real-time, *in situ* colon pH. A novel yet low-risk aspect of this research is that we will repurpose the Bravo™ gastro-esophageal reflux sensor (Medtronic, Inc.) so that it is implantable in the colon. The pH response of the colon to changes in fiber content will be monitored using the Bravo™ capsule, which will be repurposed for implantation by attaching a suture thread to a modified tissue suction hole and by adding two batteries to increase the data acquisition time from 4 to 12 days (**Fig. 2**).

2. Sensor implantation and pig diet: The study will involve 6 female pigs, divided into a control group and treatment group. Treatment group pigs will receive an implanted pH sensor, monitored via bi-weekly radiographs or until sensor expulsion. Pre-surgery, pigs will consume an electrolyte-rich liquid diet for 48 hours. During laparotomy, the sensor will be secured to the cecum wall through a cecotomy. Postoperative checks will confirm sensor placement and monitor pigs for discomfort. Pigs will have continuous access to food and water. At study completion, pigs will be euthanized for trauma examination, with a cecum section taken for microscopic study.

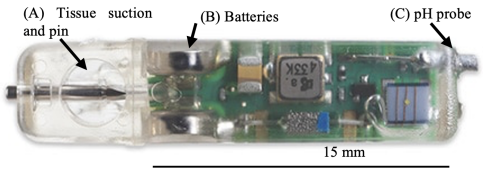

Fig. 2. Bravo™ Calibration-free reflux testing capsule (Medtronic, Inc.). The sensor will be modified for the experiment by 1) Removing the stock tissue suction hole (A) and replacing it with a loop for suturing it to the LI; 2) Adding two batteries to triple the acquisition time from 4 days to 12 days.

3. Colonic probiotic dynamics experiment: The main experiment will be to dose the treatment group pigs with a probiotic while the control pigs receive a sham treatment (**Table 2**). The main probiotic we will

administer will be SymProve, which contains 4 strains of lactic acid bacteria that increase acid production in an *in vitro* model of the colon pH at a dosage of 10^9 CFU ml^{-1} in a 5 mL dose[22]. We will closely monitor pH changes for 24 hours and statistically compare the detected pH between groups in running windows of 15-minute blocks of time. We expect that this window will be sufficient to detect a change in pH because probiotic effects, including for the pig microbiota, usually occur and drop off within ~ 24-48 hours[23]. If a pH change is detected, it provides definitive evidence that the sensor can detect probiotic-dependent pH changes in the host. Then, we will use the next 13 days to better understand the real-time effects of the probiotic by re-administering the same probiotic at different doses; and by giving the pigs a different probiotic or diet (more fiber = more acid production = lower pH) (**Table 2**). We anticipate that a different microbiome-based challenge can be administered every 24 hours based on the dogma that probiotics persist in a human for ~ 24-72 hours[24]. We will also collect daily fecal samples that will be analyzed for pH, microbial composition, and metabolomic composition to understand how these measurements correlate with *in-situ* colon pH changes. Fecal sample readings will be compared with the average gut sensor readings over the previous 24 to 48 hours (based on gut transit time of 36 hours in humans, can be longer in pigs)[24]. This approach will help determine whether dose variations influence the timing and extent of probiotic impact on colon pH. Additionally, at euthanasia we will collect a final cecum and fecal sample for pH, microbiome, and metabolomic analysis. The cecal samplings will be useful to establish a standard curve to compare pH readings from dissected animals with the sensor data, and to determine if there are discrepancies between the Bravo device readings and the benchtop meter. All samples will be stored at -80°C until they are analyzed using our standard procedures for microbiome and metabolomimc analytics[25,26].

Table 2. Scheme to apply microbiome-based interventions to pigs.

Day:	1	2	3	4	5	6	7	8	9	10	11	12	13
Control	Sham	Sham	Sham	Sham	Sham	Sham	Sham	Sham	Regular chow	Regular chow	Rest day	Regular chow	Regular chow
Treatment	10^9 CFU Symprove	10^{11} CFU Symprove	10^7 CFU Symprove	Probiotic B (10^9)	10^9 CFU Symprove	10^{11} CFU Symprove	10^7 CFU Symprove	Probiotic B (10^9)	High fiber diet	High sugar diet	Rest day	High fiber diet	High sugar diet

All animal work will be performed at IBEX Preclinical Research, Inc. in Logan, UT under the direction of Josh Packer, DVM, and in close consultation with the BYU researchers, a work model we have established in previous projects between the Terry Research lab and IBEX.

4. Measures of success: We expect that readings of colon pH levels via the Bravo pH sensor will report decreased pH in pigs administered the probiotic. The timing and magnitude of these changes will provide the first real-time insight into the dynamics of probiotic influences on a host trait.

5. Potential problems and alternative strategies: We may need to pivot if outcomes differ from our expectations. First, if the pH differs between the control and treatment groups for longer than 24 hours, we will push back additional microbiome challenges until the treatment group pH returns to control group levels. This may reduce the number of microbiome challenges we can apply but provides crucial information about the duration of the effect of the microbial challenge. Second, if the pH sensor does not report a pH change in the treatment group, either the sensor is insufficiently sensitive to the microbiome challenge or the fecal pH change begins downstream of the cecum in the GI tract. We will use pH measurements in the feces to ensure our probiotics change feces pH; if not, we need a stronger intervention and will move directly to dietary interventions with a high-fiber diet while the control pigs remain on regular chow. If the dietary intervention does not influence the pH readings in the treatment group pigs, it suggests that the gut pH change is downstream of the cecum and work outside the scope of the IDR will address this; the IDR will have provided critical preliminary information directing future work to the colon, rather than the cecum.

V. Aim 2: Design an in vitro validation of a swallowable capsule that activates in the cecum.

In our previous work, we developed a prototype of a novel, ingestible capsule that activated in the SI for the purpose of sensor implantation or drug delivery. It was subjected to a series of successful pilot studies[16–

[21,27]. The capsule contained a single Eudragit pH-sensitive film that dissolved once it reached the pH-neutral environment of the SI[19]. The dissolution of this film initiated a tissue attachment sequence for implanting a biosensor in the SI. The goal of this aim is to enable the delivery of a pH sensor to the cecum rather than the SI via the design and *in vitro* testing of a new pH-sensitive film and capsule. The new film will be a bi-layer system that dissolves only when exposed first to neutral pH (SI) then subsequently to low pH (cecum).

Research hypotheses: *Our hypotheses are that a bi-layer pH-sensitive Eudragit film, designed for our ingestible capsule, will stay intact in the stomach's acidic pH (1.5 to 3.5). Once the capsule moves into the small intestine's neutral pH (6 to 7.4) and then into the cecum's slightly acidic environment (5.5 to 7), the film will dissolve in two stages.* This process will trigger a reliable activation of the capsule's sensor attachment mechanism in the cecum.

Rationale and general approach: A capsule capable of activating upon reaching the cecum is essential to our overall objective of long-term, real-time, *in situ* analysis of the cecal microbiome and its dynamic responses to therapeutic or dietary alterations. Our general approach will be to: 1) Design, fabricate, and test a bi-layer Eudragit film for cecal activation; 2) Fabricate a capsule that integrates a TAM and the new film; 3) Validate the integrated capsule in a physiological bench-top analog of the human GI tract.

Aim 2 methodology: The methodology of Aim 2 includes designing and testing a novel bi-layer film for capsules targeting the cecum, integrating this film into our previously designed tissue attaching capsule, and testing this integrated capsule *in vitro*.

1. Designing, fabrication and testing of the bi-layer film: The fabrication of a cecum-targeted, bi-layer Eudragit film involves preparing two separate 5% w/v Eudragit solutions (L100-55 for the upper layer and E PO for the lower layer) in a 3:1 v/v methanol-dichloromethane solvent with 3% v/v liquid plasticizer. The upper and lower layers will be tuned to dissolve in a pH of > 7.5 and a pH of < 7.0, respectively. Each solution will be poured into Teflon casting molds for initial solvent evaporation, followed by near-infrared (NIR) curing (Adphos, NIR126-250 M3), adjusting power from 150 to 1700 Watts for uniform thickness. The cured films will be joined using a biocompatible adhesive and integrated into a 3D-printed capsule with UV-cured glue, ensuring that only the film contacts the intestinal fluids and chyme (refs). Film mold thickness will be designed based on expected capsule transit time in the SI. The film will be evaluated by exposing it successively to pH-neutral then low-pH solutions and measuring dissolution time at each stage.

2. Fabrication of the integrated cecum capsule: The tissue attachment mechanism (TAM) that has been used in past work[17,18,20] will be incorporated with the new bi-layer film of this work into a new capsule. The bi-layer film will be impregnated with pockets of 0.05 ml methylene blue (MB) solution between each layer that will be released to measure the film dissolution time. The capsule dimensions will be of FDA-approved swallowable size 000 (26.1 mm in length x 9.91 mm in diameter) or smaller.

3. In vitro validation of the integrated cecum capsule: The integrated cecum capsule will undergo *in vitro* testing using a GI bench-top analog. This analog comprises plastic tubing for the esophagus and SI, and pouches for the stomach and cecum, all roughly anatomically correct in size and structured from transparent 2 mil plastic. Each section will contain water with pH adjusted by hydrochloric acid or sodium hydroxide and separated by rubber bands to simulate the pylorus and ileocecal valve. The entire GI tract analog will be 7 meters long. Six cecum capsules will be manually palpated through this analog to mimic peristalsis for validation. The capsules will release MB in the SI and cecum, indicating film dissolution and triggering the TAM. The test will conclude with the start of the attachment sequence.

3.1 Statistical analyses: A binary outcome (success or failure) of the bi-layer shell dissolution within the cecum will be analyzed using a binomial test. Next, using Kaplan-Meier survival analysis, we will analyze time-to-event data regarding the bi-layer shell dissolution (indicated by the release of MB). Any variation observed in the dye emission time will be assessed for statistical significance using the log-rank test.

4. Measures of success: The measure of success for Aim 2 is the successful demonstration of a novel, ingestible capsule's bi-layer pH-sensitive film dissolving at targeted stages within a GI tract analog, thereby accurately initiating an attachment sequence in the cecum. Success will be statistically validated by binary

outcomes of bi-layer shell dissolution and time-to-event analyses, indicating the capsule's precise activation and functionality for potential therapeutic and diagnostic applications *in situ*.

5. Potential problems and alternative strategies: Adverse outcomes include potential capsule malfunctions like premature or delayed MB release or incorrect capsule placement. Results will guide further capsule refinement, including adjustments to the Eudragit layer's composition, thickness, cure time, and temperature. The capsule will then undergo a second round of *in vitro* testing.

VI. Expected project outcomes

External funding proposal: The IDR will provide our team with the data suggested by reviewers of our NIH proposal reviewed in 2023 ("Non-obstructing, retainable capsules for real-time, continuous, locale-specific GI assessment," R01, PA-20-185). We will also pursue the R15 funding mechanism to the same.

Conference presentations: The results of this work will be presented at the "Design of Medical Devices (DMD)" conference (2025, 2026), the "10th Beneficial Microbes Conference" (2024), and the "Human Microbiome: Diversity, Selection and Adaptation, a Keystone conference" (2025).

Scholarly articles: We will submit a manuscript of the device-related work to the ASME Journal of Medical Devices. The animal study results will be submitted to Frontiers in Microbiology or mSystems.

Student mentoring: The sensor implant design (Aim 1), bi-layer film design, testing, and implementation (Aim 2) portions of the work will be performed by an undergraduate student in Dr. Terry's lab under his supervision. This student will also assist with the animal studies. Drs. Chaston and Weber will mentor 1 undergraduate each who will perform the pH study associated with Aim 1 under their supervision.

Scientific outcomes: This work develops a non-invasive, real-time monitoring system for the gut microbiome which will enable personalized dietary strategies for autoimmune disease management. In addition, this work will enhance our understanding of probiotics' impact on gut pH and microbiome composition, leading to improved treatments for GI disorders. This work will be the first to introduce capsule technology for long-term, non-obstructive monitoring in the GI tract, revolutionizing in vivo analysis and therapeutic interventions.

Table 3: IDR work schedule

Study quarter	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**
Aim 1: Prep pH capsule	■	■						
Aim 1: Probiotic experiment			■	■				
Aim 1: Analyze and compile results					■	■		
Aim 2: Design/build of cecum-specific capsule		■	■					
Aim 2: In vitro test of cecum-specific capsule				■	■			
Aim 2: Analyze and compile all results						■		
Preparation of manuscripts and proposals						■	■	■

VII. Work schedule: The schedule for this work is shown in **Table 3**.

VIII. Study team

Our interdisciplinary team combines mechanical and mechatronic medical device expertise with microbiological and immunological knowledge necessary for the advancement and creation of a groundbreaking tool for personalized nutrition and therapy.

Benjamin Terry is a mechanical engineer with two decades of medical device experience. His academic work has focused on novel surgical tool design, swallowable mechatronic devices, and the *in vitro* as well as in vivo biomechanical characterization and modeling of GI tissue. He will oversee the project and coordinate between Drs. Chaston, Weber, and Packer.

John Chaston is a microbiologist with two decades of experience monitoring and dissecting the ecology of animal microbiomes, including live-monitoring in fistulated ruminants. He will oversee the students who perform the microbiome manipulations, monitoring and detection, and real-time pH analysis. He will work collaboratively to support other aspects of the proposal as needed.

Scott Weber is an immunologist with two decades of experience examining the interplay between the immune system and microbes. He will help mentor the students performing the microbiome manipulations, monitoring and detection, and real-time pH analysis. He will also work collaboratively to provide insights of these results on future immune-based paths this proposal can examine.

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Study Budget

Item	Year 1	Year 2	Total
Undergraduate student support (3)	32,000	32,000	64,000
Animal surgeries, housing, and care	20,000	20,000	40,000
Microbiome analysis and amino phenotyping	5,000	5,000	10,000
Supplies	3,000	3,000	6,000
Total	**60,000**	**60,000**	**120,000**

Budget Narrative

A total of $120,000 is requested over the 2-year span of this proposal. Of this amount, $64,000 is requested to support 3 undergraduate students (~13 hrs/week x 96 weeks x $17/hr x 3 students). Drs. Terry, Chaston, and Weber will each mentor and supervise 1 of these 3 undergraduate students. Aim 1 will be performed by Drs. Chaston's and Weber's students and Aim 2 will be performed by Dr. Terry's student. All students will collaborate to some degree on all aims. A total of $40,000 is requested to support the purchase and care of 6 human-sized pigs for the multi-week animal study in Aim 1. These funds will be paid to IBEX Preclinical Research, Inc. in Logan, Utah. These funds will also support the surgical procedures and regulatory (IACUC) approvals required to implant the pH sensors. A total of $10,000 is requested to pay for microbiome analysis and amino phenotyping required for Aim 1 as a part of the animal study. A total of $10,000 is requested for supplies to construct capsules and film materials (Aim 2), purchase probiotics for the animal study (Aim 1), and sensor modification supplies (Aim 1).

Plans for External Funding

Upon the successful completion of the IDR research objectives, we plan to leverage the IDR results as preliminary data for external funding applications, specifically targeting two distinct National Institutes of Health (NIH) mechanisms. Firstly, we aim to apply for an R01 grant from the NIH National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK), envisioning a 5-year project with an estimated $3M in direct costs, capitalizing on the mechanism's lack of direct cost limitations. Concurrently, we will pursue an R15 grant from the same NIH institute, adhering to its $300k total direct cost limit over a 3-year span. *Both proposals, prepared to align with the respective funding mechanisms' requirements, will be drafted and submitted in the concluding two quarters of the IDR research timeline.* Note that successfully completing Aim 1 will provide necessary data for the R01. Aim 2 will further strengthen the R01 submission.

The NIDDK is the appropriate choice for submitting follow-up work to because the project directly addresses the development of novel diagnostic and therapeutic tools for monitoring and manipulating the gut microbiome. This is relevant to NIDDK's mission to support research on diseases of the digestive system, including the impact of the gut microbiome on digestive health and related diseases, thus aligning with the institute's goals of advancing understanding and treatment of digestive disorders.

The R15 submission will likely focus on the engineering and preliminary in vivo validation of the bi-layer cecum sensor-delivery capsule, whereas the R01 will be far more comprehensive and will likely include aims similar to the following: Aim 1: Increase TAM attachment duration to two weeks; Aim 2: Make the sensor delivery capsule localizable; Aim 3: Characterize the dynamic response of cecal pH to a fiber-modulated diet and probiotics in a porcine model.

The submission deadlines for R01 resubmissions are March 5, July 5, and November 5, whereas the R15 deadlines are February 25, June 25, and October 25. We will submit these proposals to whichever cycle corresponds to the 7^{th} and 8^{th} quarters of the proposed IDR work.

BIOGRAPHICAL SKETCH

Provide the following information for the Senior/key personnel and other significant contributors.
Follow this format for each person. **DO NOT EXCEED FIVE PAGES.**

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eRA COMMONS USER NAME (credential, e.g., agency login): bterry2

POSITION TITLE: Associate Professor of Mechanical Engineering

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable. Add/delete rows as necessary.)*

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	Completion Date MM/YYYY	FIELD OF STUDY
Brigham Young University (BYU)	B.S.	08/1997	Mechanical Engineering
Colorado School of Mines (CSM)	M.S.	08/1999	Engineering Systems
University of Colorado-Boulder (CUB)	Ph.D.	05/2012	Mechanical Engineering

A. Personal Statement

I have significant expertise with experimental design, translational medical science, and applied research due to nine years of experience in the medical device industry and 12 years of academic experience as a PI researching and developing therapeutic and diagnostic medical devices for the gastrointestinal (GI) tract and abdominal cavity. These skills will translate well to this proposal, which if successful, could have significant impact as it provides microbiome researchers with a platform for implanting proprietary sensors in the GI tract for real-time monitoring based on continuous (rather than single sample) microbiome feedback response. Another output of this proposal will be a bi-layer pH-sensitive film that enables swallowable capsules that autonomously and non-invasively deploy non-obstructing, long-term biosensors to the lining of the small or large intestine. In general, the capsule will enable new applications for understanding gut health. Understanding real-time, continuous, gut response to pre- and probiotics is just one such application.

1. Mau, M. M., Sarker, S., Harris, S., and Terry, B. S., 2023. "Design and Testing of a Superelastic Nitinol Tissue Attachment Mechanism for Long-Term Gastrointestinal Device Retention." ASME. *J. Med. Devices*. June 2023; 17(2): 021005.
2. Patent: B. Terry, W. Lewis, W. Xie, P. LI, and A. Tsubaki, “Gastrointestinal Sensor Implantation System,” US20190150841A1, May 23, 2019.
3. Sarker, S., Wankum, B., Perey, T., Mau, MM., Shimizu, J., Jones, R., Terry, B., 2021, "A Novel Capsule-Delivered Enteric Drug-Injection Device for Delivery of Systemic Biologics: A Pilot Study in a Porcine Model," IEEE Transactions on Biomedical Engineering, doi: 10.1109/TBME.2021.3129653. (Cover article, June 2022).
4. Sarker, S., Wankum, B., Shimizu, J., Jones, R., Terry, B., 2021, “A Factorial Approach for Optimizing the Design Parameters of a Tissue Attachment Mechanism for Drug Delivery,” IEEE Transactions on Biomedical Engineering. DOI: 10.1109/TBME.2021.3086975. (Cover article, January 2022).

B. Positions, Scientific Appointments, and Honors.

Positions and Employment

2022-present Associate Professor, Department of Mechanical Engineering, BYU
2018-2022 Associate Professor, Department of Mechanical and Materials Engineering, UNL
2012-2018 Assistant Professor, Department of Mechanical and Materials Engineering, UNL

2008-2012 Graduate Researcher, Department of Mechanical Engineering, University of Colorado, Boulder
2004-2008 Senior Research and Development Engineer, Evergreen Research, Inc., Golden, Colorado
1999-2004 Research and Development Engineer, Evergreen Research, Inc., Golden, Colorado

Honors

2021 2021 UNL College of Engineering, Research Excellence Award
2020 UNL College of Engineering, College Faculty Research & Creative Activity Award.
2018 UNL NuTech Ventures Prem S. Paul Innovator of the Year award.
2016 UNL Mortar Board Professor of the Month, March.
2016 UNL College of Engineering Tau Beta Pi Distinguished Teaching Award.
2015 UNL College of Engineering Henry Y. Kleinkauf Family Distinguished New Faculty Teaching
2014 Outstanding Mechanical & Materials Engineering Faculty Award, UNL Pi Tau Sigma

C. Contributions to Science

1. The movement of commercial capsule endoscopes (CE) through the GI tract is passive and a function of intestine peristalsis. To complete more accurate diagnoses and treatment of chronic diseases, the CE, and swallowable mechanical capsules in general, must offer controllable retention, long-term (multi-week) data collection, and drug delivery functions. My contribution to this field was to solve the problem of non-obstructing, non-invasive, safe, long-term retention of CEs to the intestinal wall using bioinspiration from the scolex of the intestinal parasites.

    a. Terry, B., 2018, "Measurements for a Healthy Gut," Nature Electronics, pp. 1-2, DOI: 10.1038/s41928-017-0012-x.
    b. Xie W., Racz G. R., Terry B. S., and Gardner S. L., 2016, "A method for measuring the attachment strength of the cestode Hymenolepis diminuta to the rat intestine," Journal of Helminthology, pp. 1–5. DOI: 10.1017/S0022149X1600078X.
    c. Barducci, L., Norton, J., Sarker, S., Mohammed, S., Jones, R., Valdastri, P., Terry, B., 2020, "Fundamentals of the gut for capsule engineers," Progress in Biomedical Engineering, DOI: 10.1088/2516-1091/abab4c.
    d. Xie W., Lewis W. M., Kaser J., Welch C. R., Li P., Nelson C. A., Kothari V., and Terry B. S., 2017, "Design and Validation of a Biosensor Implantation Capsule Robot," Journal of Biomechanical Engineering. DOI: 10.1115/1.4036607.

2. The state-of-the-art in enteroscopic surgery and therapeutic care continues to minimize invasiveness, cost, surgery time, and patient trauma. To this end, a new class of medical device, called the robotic capsule endoscope, is being pursued by multiple research groups. These swallowable devices will radically expand the capabilities of natural orifice surgery by performing non-invasive tasks within the gastrointestinal (GI) tract that are now only possible with enteroscopic, laparoscopic, or open surgery. My contribution to this field was to characterize the active and passive mechanical and interfacial properties of the small intestine with the goal of accelerating the development of *in vivo* robotic capsule endoscopes for the GI tract

    a. Slawinski, P., Oleynikov, D., Terry, B., "Intestinal biomechanics simulator for robotic capsule endoscope validation," Journal of Medical Engineering and Technology, 2015, DOI: 10.3109/03091902.2014.973619.
    b. Terry, B.S., Lyle, A., Schoen, J., Rentschler, M.E., "Preliminary Mechanical Characterization of the Small Bowel for In Vivo Mobility," ASME Journal of Biomechanical Engineering, Volume 133, Issue 9, 091010, 2011, DOI: 10.1115/1.4005168.
    c. Yang Liu, Jiyuan Tian, Luigi Manfredi, Benjamin S. Terry, Shyam Prasad, Imdadur Rahman, Wojciech Marlicz, Anastasios Koulaouzidis, "A survey of small bowel modelling and its applications for capsule endoscopy", Mechatronics, Volume 83, 2022, 102748,ISSN 0957-4158, DOI: 10.1016/j.mechatronics.2022.102748.
    d. Terry, B.S., Schoen, J., Rentschler, M.E., "Characterization and Experimental Results of a Novel Sensor for Measuring the Contact Force from Myenteric Contractions," IEEE Transactions on Biomedical Engineering, 2012, DOI: 10.1109/TBME.2012.2195179.

BIOGRAPHICAL SKETCH

Provide the following information for the Senior/key personnel and other significant contributors.
Follow this format for each person. **DO NOT EXCEED FIVE PAGES.**

NAME: Chaston, John M.

eRA COMMONS USER NAME (credential, e.g., agency login): CHASTON

POSITION TITLE: Associate Professor, Genetics, Genomics & Biotechnology

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable. Add/delete rows as necessary.)*

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	Completion Date MM/YYYY	FIELD OF STUDY
Brigham Young University, Provo, UT	B.S.	2005	Microbiology
University of Wisconsin-Madison	Ph.D.	2011	Microbiology
Cornell University	Postdoctoral	2014	Bioinformatics

A. Personal Statement

The proposed work draws on my demonstrated expertise investigating the genetics and ecology of host-microbe interactions. My lab at Brigham Young University (BYU) has helped to establish the *Drosophila melanogaster* microbiota as a model for studying the ecology of host-microbe interactions, including by developing foundational tools and protocols in this field. Two of the most important contributions we have made to this field are that we showed th**e microbiota influence host life history tradeoffs and are an agent of natural selection** on their animals hosts. **We also developed a fruit fly 'probiotic' that extend animal lifespan** by producing an enzyme that metabolizes a metabolite, produced by the host, that shortens animal lifespan. In addition, we have also studied vertebrate host-microbe interactions in humans, mule deer, alpacas, and turkeys. The work in this proposal addresses key, longstanding issues in ecology of the microbiota, with a goal of using the proposed framework to interrogate these processes in humans. These efforts dovetail nicely with my major work in the ecology and 'probiotics' of the *Drosophila* microbiota. Specifically, PI-Terry's deployable device will provide real-time *in situ* measures of probiotic and prebiotic interventions on a model mammalian host. If we can establish an experimental framework to use this device to understand the duration and magnitude of probiotic influences on pigs, in this proposal, the same approaches can be used to safely investigate these processes in living, healthy humans. **The field's current inability to understand how long and how much probiotics influence host traits is a major barrier to the methodical and empirical use of probiotics to improve human health**. My long-standing expertise in the field is well suited to apply to the questions PI-Terry's experimental framework makes accessible. The following are of key relevance to this expertise from among my 45 peer-reviewed publications:

1. Walters, AW, RC Hughes, H Wilcox, S Petersen, TB Call, CJ Walker, S Rudman, PD Newell, AE Douglas, PS Schmidt, **JM Chaston**. 2020. The microbiota influences the *Drosophila melanogaster* life history strategy. *Molecular Ecology*. 29(3): 639-653. PMID 31863671.
2. Rudman, SM, S Greenblum, RC Hughes, S Rajpurohit, O Kiratli, DB Lowder, SG Lemmon, DA Petrov, **JM Chaston**, PS Schmidt. 2019. Microbiome composition shapes rapid genomic adaptation of *Drosophila melanogaster*. *The Proceedings of the National Academy of the Sciences of the United States of America*. 116(40):20025-32. PMID 31527278.
3. Matthews, MK, H Wilcox, RC Hughes, M Veloz, A Hammer, B Banks, A Walters, KJ Schneider, CE Sexton, **JM Chaston**. 2020. Methionine-restriction-dependent and -independent influences of the microbiota on *Drosophila melanogaster* lifespan. *Applied and Environmental Microbiology*. 86(10):e00305-20. PMID: 32144104
4. **Chaston, JM***, PD Newell*, AE Douglas. 2014. Metagenome-wide association of microbial determinants of host phenotype in *Drosophila melanogaster*. *mBio*. 5(5):e01631-14. PMID: 25271286

* Equal contributions

B. Positions, Scientific Appointments, and Honors

Positions

2020-present Associate Professor, Brigham Young University, Provo, UT
2014-2020 Assistant Professor, Brigham Young University, Provo, UT

Other appointments and honors

2021 Sam and Aline Skaggs Distinguished Mentoring Fellowship, College of Life Sciences
2015-present Member, Genetics Society of America
2015-present Editorial Board, Applied and Environmental Microbiology
2012-present Member, American Society for Microbiology
2008. National Institutes of Health (T32) Microbes in Health and Disease Predoctoral Trainee
2006 National Science Foundation Graduate Research Fellow

C. Full publication list:

https://www.ncbi.nlm.nih.gov/myncbi/1hE-pKlOcydQu/bibliography/public/

1. The role of the microbiota in animal evolution

A hypothesis that has received much attention but only limited demonstration is that animal-associated bacterial communities influence animal evolution. This has been clearly shown for bacterial partners that are obligate with or transmitted maternally within their animal hosts. However, there was not a clear experimental demonstration of this idea in animals that bore a transient gut microbiota. Using natural fly populations reared in outdoor enclosures we closed this gap by showing that **the gut microbiota can act as an agent of host selection.** We also showed that the flies must manage their microbial communities if they are to adopt their genetically adapted life history strategies since disruption of these communities caused them to display maladapted phenotypes. Together, the goal of these and the work outlined in this proposal are to understand and explain how the microbiota are a key component of life history evolution in *D. melanogaster*, a key model organism for describing life history evolution and local adaptation.

1. Walters, AW, RC Hughes, H Wilcox, S Petersen, TB Call, CJ Walker, S Rudman, PD Newell, AE Douglas, PS Schmidt, **JM Chaston**. The microbiota influences the *Drosophila melanogaster* life history strategy. *Molecular Ecology*. 29(3): 639-653. PMID 31863671.
2. Rudman, SM, S Greenblum, RC Hughes, S Rajpurohit, O Kiratli, DB Lowder, SG Lemmon, DA Petrov, **JM Chaston**, PS Schmidt. 2019. Microbiome composition shapes rapid genomic adaptation of *Drosophila melanogaster*. *The Proceedings of the National Academy of the Sciences of the United States of America*. *1*16(40):20025-32. PMID 31527278.

2. Genetic interrogation of host-microbe interactions in *Drosophila melanogaster*

A major imperative in microbiota research is to establish the causal basis for correlations between host phenotypes and shifts in microbial community structure. We have developed metagenome-wide association approaches in monoassociated hosts as a surrogate genetic screen to which our genetic expertise can be applied to establish causal relationships between bacterial genes and host phenotypes. Our ongoing efforts in this area have identified bacterial LPS production, glucose oxidation, and methionine metabolism as key mechanisms by which bacteria colonize *D. melanogaster* or influence its fat content or starvation resistance and lifespan, respectively. These efforts led us to develop a 'probiotic' therapy for fruit flies, where we designed and created a recombinant bacterial strain that consumed a methionine-cycle metabolite that shortens fruit fly lifespan. We also wrote our MGWA pipeline as an easy-to-use R package. **These examples show we can identify and manipulate molecular interactions between host and microbe to lead to beneficial, designed outcomes in the animal host.** I led out on or supervised all aspects of this work.

1. Call, TB, EK Davis, JB Bean, SG Lemmon, **JM Chaston**. 2022. Bacterial metabolism and transport genes are associated with the preference of Drosophila melanogaster for dietary yeast. *Applied and Environmental Microbiology*. 88(16):e0072022. PMID: 35913151.
2. Matthews, MK, H Wilcox, RC Hughes, M Veloz, A Hammer, B Banks, A Walters, KJ Schneider, CE Sexton, **JM Chaston**. 2020. Methionine-restriction-dependent and -independent influences of the microbiota on *Drosophila melanogaster* lifespan. *Applied and Environmental Microbiology*. 86(10):e00305-20. PMID: 32144104

BIOGRAPHICAL SKETCH

Provide the following information for the Senior/key personnel and other significant contributors.
Follow this format for each person. DO NOT EXCEED FIVE PAGES.

NAME: Weber, Scott

eRA COMMONS USER NAME (credential, e.g., agency login): KSWEBER

POSITION TITLE: Associate Director of Simmons Center for Cancer Research

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable. Add/delete rows as necessary.)*

INSTITUTION AND LOCATION	DEGREE (if applicable)	END DATE MM/YYYY	FIELD OF STUDY
Brigham Young University, Zoology, Provo, Utah	BS	08/1998	Zoology
Brigham Young University, Zoology, Provo, Utah	MS	08/2000	Neuroendocrinology
University of Illinois, Cell and Structural Biology, Champaign-Urbana , IL	PHD	08/2005	Cell and Structural Biology
Washington University in St. Louis, St. Louis, Missouri	Postdoctoral Fellow	08/2009	Immunology

A. Personal Statement

I am a Professor and Chair of the Department of Microbiology and Molecular Biology at Brigham Young University and the Associate Director of the Simmons Center for Cancer Research. The overall goal of my work focuses on understanding how to use molecular biology to improve immunotherapies. I mentor four graduate students and eight undergraduates in my research lab. I teach Immunology, Flow Cytometry, and Advanced Molecular Biology Lab courses and incorporate active learning to generate curiosity and excitement for science discovery. Research in my laboratory is focused on 4 main projects: 1) Engineering improved immunological proteins helpful in combating cancer and autoimmune disease, 2) Understanding the molecular basis of T cell activation, 3) Determining the role of the immune system on alcohol addiction, and 4) Molecular characterization of the function of chemokine receptors associated with Alzheimer's disease. For years my work has focused on immune cell recognition of antigen and activation. The purpose of this proposal is to characterize the ability of us to use molecular modeling software to improve our ability to develop antibody therapeutics

I obtained a master's degree in neuroendocrinology with Dr. Edwin Lephart at Brigham Young University examining the role of hormones on brain function. I was trained as a Ph.D. student in Dr. David Kranz's laboratory at the University of Illinois, where I developed expertise in molecular immunology and protein engineering generating and characterizing a panel of high affinity T cell receptors using yeast display. I was a postdoctoral fellow in Dr. Paul Allen's laboratory at Washington University in St. Louis where I developed expertise in cellular immunology and calcium imaging examining helper T cell activation using single cell ratiometric calcium imaging. I received the Midwest Regional Center of Excellence Career Development Award and became a Research Instructor at Washington University in St. Louis. I developed expertise in mouse models, pathogen-host interactions, and T cell recognition of antigen as I characterized two helper T cell receptor transgenic mice specific for the same naturally occurring Listeria monocytogenes epitope. I have been at Brigham Young University for 11 years (2012-2023). I have authored 55 manuscripts, 3 book chapters, and have obtained both on NIH R15 and R01 grant while at BYU. I am committed to student-based research. In 11 years at BYU, I have mentored 60 undergraduates, 4 master's students, and 5 Ph.D. students.

I am confident in our ability to successfully complete the aims of this proposal and contribute key insights into improving real time monitoring of microbiome influences such as pH. This project harness expertise from Ben Terri's engineering lab, John Chaston's microbiology lab, and my immunology lab while providing rigorous biomedical training for undergraduate and graduate students in our labs.

B. Positions, Scientific Appointments and Honors

Positions and Scientific Appointments

2023 - Present	Department Chair, Brigham Young University, Microbiology and Molecular Biology, Provo, UT
2023 - Present	Professor, Brigham Young University, Microbiology and Molecular Biology, Provo, UT
2022 - 2022	Interim Director of the BYU Life Science Research Instrument Core, Provo, UT
2020 - Present	Associate Director of Simmons Center for Cancer Research, BYU, Provo, UT
2018 - 2023	Associate Professor, BYU Department of Microbiology and Molecular Biology, Provo UT
2012 - 2018	Assistant Professor, BYU Department of Microbiology and Molecular Biology, Provo UT
2009 - 2013	Research Instructor, Washington University in St. Louis School of Medicine, Pathology and Immunology, St Louis, Missouri
2005 - 2009	Post-Doctoral Fellow, Washington University in St. Louis School of Medicine, Pathology and Immunology, St Louis, Missouri
2000 - 2005	Biochemistry Graduate Teaching and Research assistant, University of Illinois, Urbana, IL
1999 - 2000	Graduate Teaching and Research assistant in Neuroscience, BYU, Provo, UT

Honors

2022 - 2022	College of Life Sciences Distinguished Mentor Award, Brigham Young University
2021 - 2021	College of Life Sciences Outstanding Teaching Award, Brigham Young University
2019 - 2019	College of Life Sciences Outstanding Research Award, Brigham Young University
2013 - 2017	Academic Research Enhancement Award (R15), National Institute of Health
2013 - 2013	Microbiology and Molecular Biology high impact research award, Brigham Young University
2009 - 2012	Midwest Regional Center of Excellence Career Development Award, NIH
2005 - 2008	Ruth L. Kirschstein Postdoctoral Fellow, National Institute of Health
2003 - 2004	Pre-doctoral Cell and Molecular Biology Program Fellow, National Institute of Health
1999 - 2000	Neuroscience Dean's Fellow, Brigham Young University
1992 - 1998	Trustee's Scholarship (4-years of full tuition), Brigham Young University

C. Contribution to Science

1. Immunotherapy development. My work understanding and developing immunotherapies for the microbiome, cancer, Alzheimer's disease, and autoimmune disease has progressed with many collaborations here at BYU. At BYU we have examined the oral microbiome and how students learn immunology, genomics, and molecular biology better when examining their own microbiome data. We have also used yeast display to isolate and characterize single chain antibodies and test their ability to function as chimeric antigen receptors targeting cancer cells. We have also characterized chemokine receptors associated Alzheimer's disease risk, identified potential immunometabolism strategies for cancer therapies, and examined how the immune system affects Graves' disease. I served as the primary or co-investigator for all these studies.

    a. Moreno C[†], Bybee E[*], Freitas CMT, and Weber KS. Immunomodulatory role of the oral microbiome and its role in allergic diseases. *Frontiers in Allergy*. 4:1067483 (2023) http://doi.org/10.3389/falgy.2023.1067483
    b. Murcia JDG, Weinert A, Freitas CMT, Arens DK, Ferrel MN, Grose JH, Ridge PG, Wilson E, Kauwe JSK, Weber KS. Atypical chemokine receptor ACKR2-V41A has decreased CCL2 binding, scavenging, and activation, supporting sustained inflammation and increased Alzheimer's disease risk. Sci Rep. 2020 May 15;10(1):8019. PubMed Central PMCID: PMC7229167.
    c. Turbitt WJ, Buchta Rosean C, Weber KS, Norian LA. Obesity and CD8 T cell metabolism: Implications for anti-tumor immunity and cancer immunotherapy outcomes. Immunol Rev. 2020 May;295(1):203-19
    d. Weber KS, Bridgewater LC, Jensen JL, Breakwell D, Nielsen B, and Johnson SM. Personal microbiome analysis increases engagement and interest in Immunology, Genomics, and Molecular Biology undergraduate courses. *PLoS ONE.* 13(4): e0193696 (2018)

Complete List of my 55 publications: https://www.ncbi.nlm.nih.gov/myncbi/scott.weber.1/bibliography/public/

Current and Pending Support

Benjamin Terry

Project/proposal title: New Faculty Start-up Funds
Status of Support: Active
Source of Support: Brigham Young University
Primary Place of Performance: Brigham Young University
Start Date: 11/2022
End Date: 12/2025
Summary: Student Wages $60,000; $20,000/year for three years
Supplies: $24,000
Travel: $9,000
Capital Equipment: $180,000
PhD Stipend: $8,000
Tuition: $18,000; $6,000/year for three years
Total Award Amount: $299,000

Project/proposal title: Revolutionizing Gut Health: *In-Situ*, Real-Time Analysis of Microbiome Interactions and Therapeutic Response via an Innovative Swallowable Capsule with Tissue Attachment Mechanism
Status of Support: Pending
Source of Support: NIH NIDDK
Primary Place of Performance: Brigham Young University
Start Date: 7/1/2024
End Date: 6/30/2029
Total Award Amount: $3,089,791.74 (Includes indirect costs)
Time commitment (Person Months): 2.00 months per year

Johnny Chaston

EXTRAMURAL
Project/proposal title: (R15) The causes of geographic variation in *Drosophila melanogaster* microbiota composition
Status of Support: Active
Source of Support: NIH NIGMS
Primary Place of Performance: Brigham Young University
Start Date: 9/1/2020
End Date: 8/31/2024
Total Award Amount: $467,334.01 ($402,500.01 to Chaston)
Time commitment (Person Months): 1.00 months per year

Project/proposal title: Defining the microbiota's response to and influence on the evolution of Drosophila melanogaster
Status of Support: Active
Source of Support: NIH NIGMS
Primary Place of Performance: Brigham Young University
Start Date: 7/1/2022
End Date: 6/31/2025
Total Award Amount: $439,700 ($60,000 to Chaston)
Time commitment (Person Months): 0.50 months per year

INTRAMURAL
Project/proposal title: Trust the Gut: Developing a Simple Fecal Test to Screen Infants at Risk for Autism
Status of Support: Active
Source of Support: BYU IDR
Primary Place of Performance: Brigham Young University
Start Date: 2022
End Date: 2024
Total Award Amount: $40,000
Time commitment (Person Months): 0.50 months per year

Scott Weber

EXTRAMURAL
Project/proposal title: (R01) *Neuroimmune mechanisms of alcohol reward*
Status of Support: Active
Source of Support: NIH NAL
Primary Place of Performance: Brigham Young University
Start Date: 2023
End Date: 2028
Total Award Amount: $1,861,873
Time commitment (Person Months): 1.00 month per year

INTRAMURAL
PI Scott Weber $20,000
Project/proposal title: *Using molecular dynamic simulations to improve antibody immunotherapy effectiveness and reduce production costs*
Status of Support: Active
Source of Support: 2024 Cancer Interdisciplinary Research Grant
Primary Place of Performance: Brigham Young University
Start Date: 2024
End Date: 2024
Total Award Amount: $20,000
Time commitment (Person Months): 0.50 months per year

Project/proposal title: *Protective role of a cytokine receptor allele on Alzheimer's* disease
Status of Support: Active
Source of Support: 2023 James Bobbitt Alzheimer's Grant
Primary Place of Performance: Brigham Young University
Start Date: 2023
End Date: 2024
Total Award Amount: $20,000
Time commitment (Person Months): 0.50 months per year

Project/proposal title: Trust the Gut: Developing a Simple Fecal Test to Screen Infants at Risk for Autism
Status of Support: Active
Source of Support: BYU IDR
Primary Place of Performance: Brigham Young University
Start Date: 2022
End Date: 2024
Total Award Amount: $40,000

Time commitment (Person Months): 0.50 months per year