PI: **WANG, XIAOQIN**	Title: Bicoastal Marmoset Breeding Center	
Received: 10/03/2019	FOA: MH20-145 Clinical Trial:Not Allowed	Council: 05/2020
Competition ID: FORMS-E	FOA Title: BRAIN Initiative: Marmoset Colonies for Neuroscience Research (U24 Clinical Trials Not Allowed)	
1 U24 MH123423-01	Dual: AA,AG,AT,DA,DC,DE,EB,ES,EY, HD,NS	Accession Number: 4354714
IPF: 4134401	Organization: JOHNS HOPKINS UNIVERSITY	
Former Number:	Department: Biomedical Engineering	
IRG/SRG: ZMH1 ERB-G (03)	AIDS: N	Expedited: N
Subtotal Direct Costs (excludes consortium F&A) Year 1: 985,829 Year 2: 989,039 Year 3: 944,274 Year 4: 930,910 Year 5: 931,688	Animals: Y Humans: N Clinical Trial: N Current HS Code: 10 HESC: N HFT: N	New Investigator: Early Stage Investigator:
Senior/Key Personnel:	*Organization:*	*Role Category:*
XIAOQIN WANG	JOHNS HOPKINS UNIVERSITY	PD/PI
CORY MILLER	The Regents of the Univ. of Calif., U.C. San Diego	Co-Investigator
Jessica Izzi	Johns Hopkins University	Co-Investigator
SARAH BECK	Johns Hopkins University	Other (Specify)-Veterinarian
Eric Hutchinson	Johns Hopkins University	Other (Specify)-Veterinarian

OMB Number 4040-0001
Expiration Date 10/31/2019

APPLICATION FOR FEDERAL ASSISTANCE
SF 424 (R&R)

3. DATE RECEIVED BY STATE	State Application Identifier

1. TYPE OF SUBMISSION*

❍ Pre-application ● Application ❍ Changed/Corrected Application

4.a. Federal Identifier

b. Agency Routing Number

2. DATE SUBMITTED

Application Identifier 00130104

c. Previous Grants.gov Tracking Number

5. APPLICANT INFORMATION

Organizational DUNS*: 0019107770000

Legal Name*: JOHNS HOPKINS UNIVERSITY
Department: Biomedical Engineering
Division: School of Medicine
Street1*: 733 N Broadway, Suite 117
Street2: Edward D. Miller Research Building
City*: BALTIMORE
County:
State*: MD: Maryland
Province:
Country*: USA: UNITED STATES
ZIP / Postal Code*: 212051832

Person to be contacted on matters involving this application

Prefix: First Name*: Marisa Middle Name: Last Name*: Bailey Suffix:

Position/Title: Grants Associated
Street1*: 733 N. Broadway
Street2: Suite 117
City*: Baltimore
County:
State*: MD: Maryland
Province:
Country*: USA: UNITED STATES
ZIP / Postal Code*: 21205-1832
Phone Number*: 443-287-0982 Fax Number: Email: mabailey@jhu.edu

6. EMPLOYER IDENTIFICATION NUMBER *(EIN) or (TIN)** 520595110

7. TYPE OF APPLICANT* O: Private Institution of Higher Education

Other (Specify):
Small Business Organization Type ❍ Women Owned ❍ Socially and Economically Disadvantaged

8. TYPE OF APPLICATION*

● New ❍ Resubmission
❍ Renewal ❍ Continuation ❍ Revision

If Revision, mark appropriate box(es).

❍ A. Increase Award ❍ B. Decrease Award ❍ C. Increase Duration
❍ D. Decrease Duration ❍ E. Other *(specify)* :

Is this application being submitted to other agencies?* ❍Yes ●No What other Agencies?

9. NAME OF FEDERAL AGENCY*
National Institutes of Health

10. CATALOG OF FEDERAL DOMESTIC ASSISTANCE NUMBER
TITLE:

11. DESCRIPTIVE TITLE OF APPLICANT'S PROJECT*
Bicoastal Marmoset Breeding Center

12. PROPOSED PROJECT

Start Date* 07/01/2020
Ending Date* 06/30/2025

13. CONGRESSIONAL DISTRICTS OF APPLICANT
MD-007

SF 424 (R&R) APPLICATION FOR FEDERAL ASSISTANCE

14. PROJECT DIRECTOR/PRINCIPAL INVESTIGATOR CONTACT INFORMATION

Prefix: Dr. First Name*: XIAOQIN Middle Name: Last Name*: WANG Suffix:
Position/Title: Professor
Organization Name*: JOHNS HOPKINS UNIVERSITY
Department: Biomedical Engineering
Division: School of Medicine
Street1*: 720 Rutland Ave
Street2: Traylor 410
City*: BALTIMORE
County:
State*: MD: Maryland
Province:
Country*: USA: UNITED STATES
ZIP / Postal Code*: 21205-2109
Phone Number*: (410) 614-4547 Fax Number: (410) 614-9599 Email*: xiaoqin.wang@jhu.edu

15. ESTIMATED PROJECT FUNDING

a. Total Federal Funds Requested*	$7,469,953.00
b. Total Non-Federal Funds*	$0.00
c. Total Federal & Non-Federal Funds*	$7,469,953.00
d. Estimated Program Income*	$0.00

16.IS APPLICATION SUBJECT TO REVIEW BY STATE EXECUTIVE ORDER 12372 PROCESS?*

a. YES ○ THIS PREAPPLICATION/APPLICATION WAS MADE AVAILABLE TO THE STATE EXECUTIVE ORDER 12372 PROCESS FOR REVIEW ON:
DATE:

b. NO ● PROGRAM IS NOT COVERED BY E.O. 12372; OR
○ PROGRAM HAS NOT BEEN SELECTED BY STATE FOR REVIEW

17. By signing this application, I certify (1) to the statements contained in the list of certifications* and (2) that the statements herein are true, complete and accurate to the best of my knowledge. I also provide the required assurances * and agree to comply with any resulting terms if I accept an award. I am aware that any false, fictitious, or fraudulent statements or claims may subject me to criminal, civil, or administrative penalties. (U.S. Code, Title 18, Section 1001)

● I agree*

** The list of certifications and assurances, or an Internet site where you may obtain this list, is contained in the announcement or agency specific instructions.*

18. SFLLL or OTHER EXPLANATORY DOCUMENTATION File Name:

19. AUTHORIZED REPRESENTATIVE

Prefix: First Name*: Marisa Middle Name: Last Name*: Bailey Suffix:
Position/Title*: Grants Associate
Organization Name*: Johns Hopkins University
Department: Research Administration
Division: School of Medicine
Street1*: 733. N. Broadway
Street2: Suite 117
City*: Baltimore
County:
State*: MD: Maryland
Province:
Country*: USA: UNITED STATES
ZIP / Postal Code*: 21205-1832
Phone Number*: 443-287-0982 Fax Number: Email*: mabailey@jhu.edu

Signature of Authorized Representative*
Sharel Brown

Date Signed*
10/03/2019

20. PRE-APPLICATION File Name:

21. COVER LETTER ATTACHMENT File Name:

424 R&R and PHS-398 Specific
Table Of Contents

OMB Number: 4040-0010
Expiration Date: 10/31/2019

Project/Performance Site Location(s)

Project/Performance Site Primary Location

❍ I am submitting an application as an individual, and not on behalf of a company, state, local or tribal government, academia, or other type of organization.

Organization Name: JOHNS HOPKINS UNIVERSITY
Duns Number: 0019107770000
Street1*: 733 N Broadway, Suite 117
Street2: Edward D. Miller Research Building
City*: BALTIMORE
County:
State*: MD: Maryland
Province:
Country*: USA: UNITED STATES
Zip / Postal Code*: 212051832
Project/Performance Site Congressional District*: MD-007

Project/Performance Site Location 1

❍ I am submitting an application as an individual, and not on behalf of a company, state, local or tribal government, academia, or other type of organization.

Organization Name: JOHNS HOPKINS UNIVERSITY
DUNS Number: 0019107770000
Street1*: 720 Rutland Ave
Street2: Traylor 410
City*: BALTIMORE
County:
State*: MD: Maryland
Province:
Country*: USA: UNITED STATES
Zip / Postal Code*: 21205-2109
Project/Performance Site Congressional District*: MD-007

Funding Opportunity Number: RFA-MH-20-145. Received Date: 2019-10-03T16:24:07.000-04:00

Project/Performance Site Location 2

❍ I am submitting an application as an individual, and not on behalf of a company, state, local or tribal government, academia, or other type of organization.

Organization Name:	The Regents of the Univ. of Calif., U.C. Sand Diego
DUNS Number:	8043557900000
Street1*:	University of California San Diego
Street2:	Office of Contract & Grant Admin, 0934
City*:	La Jolla
County:	
State*:	CA: California
Province:	
Country*:	USA: UNITED STATES
Zip / Postal Code*:	92093-0934
Project/Performance Site Congressional District*:	CA-049

Additional Location(s) File Name:

OMB Number: 4040-0001
Expiration Date: 10/31/2019

RESEARCH & RELATED Other Project Information

1. Are Human Subjects Involved?* ❍ **Yes** ● **No**

1.a. If YES to Human Subjects

Is the Project Exempt from Federal regulations? ❍ Yes ❍ No

If YES, check appropriate exemption number: _ 1 _ 2 _ 3 _ 4 _ 5 _ 6 _ 7 _ 8

If NO, is the IRB review Pending? ❍ **Yes** ❍ **No**

IRB Approval Date:

Human Subject Assurance Number

2. Are Vertebrate Animals Used?* ● **Yes** ❍ **No**

2.a. If YES to Vertebrate Animals

Is the IACUC review Pending? ● Yes ❍ No

IACUC Approval Date:

Animal Welfare Assurance Number A3272-01

3. Is proprietary/privileged information included in the application?* ❍ **Yes** ● **No**

4.a. Does this project have an actual or potential impact - positive or negative - on the environment?* ❍ **Yes** ● **No**

4.b. If yes, please explain:

4.c. If this project has an actual or potential impact on the environment, has an exemption been authorized or an environmental assessment (EA) or environmental impact statement (EIS) been performed? ❍ Yes ❍ No

4.d. If yes, please explain:

5. Is the research performance site designated, or eligible to be designated, as a historic place?* ❍ **Yes** ● **No**

5.a. If yes, please explain:

6. Does this project involve activities outside the United States or partnership with international collaborators?* ❍ **Yes** ● **No**

6.a. If yes, identify countries:

6.b. Optional Explanation:

	Filename
7. Project Summary/Abstract*	ProjectSummary_U24_Oct2019.pdf
8. Project Narrative*	ProjectNarrative.pdf
9. Bibliography & References Cited	ReferencesCited.pdf
10.Facilities & Other Resources	Facilities.pdf
11.Equipment	Equipment.pdf

Funding Opportunity Number: RFA-MH-20-145. Received Date: 2019-10-03T16:24:07.000-04:00

Project Summary

The common marmoset (*Callithrix jacchus*) has experienced unprecedented growth in research across the United States and is rapidly emerging as a likely keystone biomedical model system in the next chapter of scientific discovery. Over the past decade, the number of marmoset laboratories in the US has quadrupled. There are now over 40 Principal Investigators who use marmoset as the model system in their research. Neuroscience is the primary engine driving marmoset research today, as nearly three quarters of marmoset researchers in the US use this model species to examine molecular, systems or cognitive functions in normal and diseased brains. Although these grassroots have been successfully forged new paths of scientific inquiry using marmosets in the U.S., critical bottlenecks have emerged that threaten to thwart the continued growth of this emerging model system. We propose to establish a Bicoastal Marmoset Breeding center, with two breeding colonies, one on the East Coast at Johns Hopkins University (JHU) and the other on the West Coast at University of California at San Diego (UCSD). The Center aims to produce a large number of marmosets to supply the marmoset research community in the U.S. Because of the non-availability of air transport of NHP in U.S. and prohibitively expensive ground transportation of NHP between the east and west coast, these two breeding colonies are strategically located to support the marmoset community in regions near each colony. We believe such a center *i*s needed to address the national shortage of marmosets in order for the marmoset model to realize its full potential as a keystone species in the next chapter of neuroscience that serves to accelerate the rate of discovery and better understand human neurological disease.

Public Health Relevance Statement:

A proper model system is crucial to advance the studies of human neuropsychiatric diseases. The proposed project will contribute to the research in this field by making critical resource available to neuroscience research community.

Laboratory:

Wang Lab: Dr. Wang's laboratory (~2000 sq. ft.) has several full-size soundproof chambers for conducting behavioral and single-unit recording studies in awake marmosets, a large RF/EMI/Acoustic shielded chamber for conducting wireless neural recording experiments in freely roaming marmosets, all fully equipped with computers and hardware, capable of generating well-controlled acoustic stimuli and performing neurophysiological recordings. The lab has acess to MRI scanners in [proprietary/confidential] which houses a 11.4T small animal scanner that is suitable for marmosets.

Miller Lab: Dr. Miller's laboratory has 4 testing rooms, an observation area, a colony room, electronics workbench and a clean room for data analysis. Each testing room is equipped with multiple video cameras for monitoring subjects during testing. The lab is also equipped with a downdraft table for perfusing animals following the conclusion of experiments. The electronics bench is equipped with an electronics scope, moveable hood arm and all the necessary tools for constructing the microelectrode arrays. The lab has acess to the UCSD Histology Core and the UCSD Center for Functional MRI which houses a 7T small animal scanner that is suitable for marmosets. The Center provides space for short-term housing of the animals prior to and after scanning sessions.

Animal:

Johns Hopkins University (JHU)

The [confidential/proprietary] Johns Hopkins University contains 160,000 net square feet of research space. Animals housed in this building are used in laboratories within the building, and in [confidential/proprietary]. The offices and laboratories of RAR are located on [confidential/proprietary]. There are four animal holding facilities in the building, which encompass a total of 18,977 net square feet of space. These holding areas are located on [confidential/proprietary] rooms hold both small and large animals, including mice, rats, rabbits, cats, dogs, swine, sheep and nonhuman primates including marmosets. [confidential/proprietary] All animal rooms are protected by a card-key security system. The marmosets are currently housed on [proprietary/confidential] large animal holding rooms (with a total of 1,728 Sq ft), with an anteroom and a dedicated procedure and husbandry room adjacent to the holding rooms. All animals are housed in USDA registered, AAALAC International accredited facilities and are maintained in rooms housing multiple breeding groups and social pairs. Additional animal holding rooms will be allocated to accommodate the proposed breeding colony.

University of California at San Diego (UCSD)

Marmoset breeding for this project will take place at the UC San Diego Elliot Field Station. This research facility located 10 miles east of the main UCSD campus. The site consists of 26.8 acres. There are 14 buildings which provide approximately 12000 sq ft of conditioned space, and 13,000 sq ft of unconditioned space. The facility includes large and small animal holding facilities, animal procedure/radiology facilities, surgical facilities, offices, storage and support space, resident caretaker trailers, large animal outdoor pens/corrals, kennels, and animal housing and procedure facilities. Nonhuman primates including marmoseta are routinely housed in the conditioned space, including marmosets. 3000 sq ft are available at the UCSD Elliot Field Station for this breeding project. We will be allocated 1000sq ft in year 1, 2000 in year 2 and the full space by year 3 to accommodate the growing colony size. Elliot Field Station has portable emergency generators available for long term power outages. Several layers of security are in place including 24-hour on-site staff, security cameras and biometric recognition access systems which is directly connected to our centralized security systems. Security fencing has three separate layers in order to gain access to the animal housing facilities. Each of those are locked and some are additionally secured with intrusion detectors. All the animal facilities at UCSD are AALAC accredited.

Computer:

Wang Lab: There are a total of ~20 computers in the laboratory; 10 are devoted for behavioral and electrophysiological experiments and the rest are available for data analyses.

Miller Lab: For data analysis, my laboratory consists of 4 iMac computers and 2 custom data analysis PCs (128GB RAM, 24TB Harddrive, Intel 16-core processor). Each of the 4 testing chambers also has a custom build PC for performing experiments (16GB RAM, 4TB Hard drive, Intel 4 or 8-core processor). The lab also has a 12-Core data server housed outside the lab that all data are backed up to each evening. Computers are equipped with all the necessary software (Matlab, Adobe CS4, RAVEN, etc).

Office:

Wang Lab: Adequate office space (~600 sq. ft.) for all personnel is located adjacent to the laboratory and colony rooms.

Miller Lab: Miller has an office outside the primary lab but in the same building as the main laboratory (McGill Hall) . Office space is provided by the Psychology department for UCSD graduate students and Post-docs. Research assistants have desk space in the main laboratory. A desk in a shared office will also be provided at Elliott Field Station to enable oversight of the breeding colony housed at that location.

Other:

Wang Lab: The P.I.'s laboratory is part of the Johns Hopkins University Center for Hearing and Balance. The P.I. has access to shared facilities (e.g. surgical suite, electronic shop, histology core facility) operated by the Center for Hearing and Balance. The Biomedical Engineering Department maintains a machine shop in the building, managed by a skilled machinist; some machines (lathe, mill, drill press, bandsaw, etc.) are available to the P.I. (pay-for-service at an hourly rate). The machine shop is experienced in making devices and parts used in chronic recording experiments. The P.I.'s laboratory has an active collaboration with Dr. Stewart Hendry's neuroanatomy laboratory at the Mind Brain Institute in Johns Hopkins University.

Miller Lab: The Miller lab is a part of the Cognitive Neural Systems group in the Department of Psychology and the Neurosciences Graduate Program. The former meets weeks to either hear talks from outside speakers or hear presentations of from students or post-docs from one of the 10 labs in this group (Anagnostaris, Aron, Gentner, Gremel, Miller, Reinagel, Serences, Voytek, Vul, Saygin). The Neuroscience Seminars provide weekly talks and opportunities for interactions with the broader neuroscience faculty across the campus. The machine shop at UCSD and Scripps Institute of Oceanography have each fabricated material for the laboratory. Both are available for any custom machining needed for this study.

Equipment

Wang Lab (JHU):

- Three full-size soundproof chambers (IAC-1204) for conducting neural recording experiments or combined behavior-physiology experiments, one of which is specifically configured to measure full-field spatial receptive fields using a 24-speaker free-field speaker array. Two small soundproof chambers for conducting behavioral training. Each of the soundproof chambers is equipped with computer-controlled stimulus generation and data acquisition systems (Tucker-Davis Technologies). All sound signals are generated using a customized Matlab program (Mathworks) and delivered at a nominal sampling rate of 100kHz at 16-bit through a DAQ card (National Instruments, PICe-6323), followed by a programmable attenuator (Tucker Davis Technologies, PA5), and an audio amplifier (Crown Audio, model D-75A).

- Several microdrives, amplifiers, oscilloscopes and other equipment for neural recording experiments.

- Two eye tracking systems (I-SCAN) for monitoring animal's behaviors.

Miller Lab (UCSD):

- A large RF/EMI/acoustic shielded chamber (Series 81, ETS Lindgren, dimensions of 8x16x8 ft) for conducting wireless neural recording experiments. The inner walls, ceiling and floor of the chamber is lined with 5-inch thick RF absorption cones (EHP-5CV, ETS Lindgren) which absorb reflected radio waves within the chamber. This chamber eliminates most inference sources to the radio frequency link of the neural telemetry system. This chamber will be used for Aims 2 and 3.

- A large anechoic chamber (8'x8x6') will be used for conducting the cross-modal experiments in restrained animals described in Aim 1. This chamber isolates subjects from all visual and acoustic signals external to the test environment.

- The lab is equipped with Intan neurophysiology hardware and TBSI wireless nerual recording system for all neurophysiology experiments. This preparation includes microelectrode arrays, headstage, tether, amplifiers and NI data acquisition cards. Custom software in Matlab is used to perform stimulus presentation and data collection.

- The lab is also equipped with all computers and hardware necessary for the MRI components of the experiments, such as MR compatible headphones, cradle and custom marmoset MR coils.

- Subjects' social behavior is recorded using a 18 infra-red camera Opitrac visual tracking system. This systems allows the optical tracking of multiple animals in the test environment.

OMB Number: 4040-0001
Expiration Date: 10/31/2019

RESEARCH & RELATED Senior/Key Person Profile (Expanded)

PROFILE - Project Director/Principal Investigator

Prefix: Dr. First Name*: XIAOQIN Middle Name Last Name*: WANG Suffix:

Position/Title*: Professor
Organization Name*: JOHNS HOPKINS UNIVERSITY
Department: Biomedical Engineering
Division: School of Medicine
Street1*: 720 Rutland Ave
Street2: Traylor 410
City*: BALTIMORE
County:
State*: MD: Maryland
Province:
Country*: USA: UNITED STATES
Zip / Postal Code*: 21205-2109

Phone Number*: (410) 614-4547 Fax Number: (410) 614-9599

E-Mail*: xiaoqin.wang@jhu.edu

Credential, e.g., agency login: [redacted]

Project Role*: PD/PI Other Project Role Category:

Degree Type: PHD Degree Year: 1992

Attach Biographical Sketch*: File Name: Biosketch_XiaoqinWang.pdf

Attach Current & Pending Support: File Name:

Tracking Number: GRANT12945120
Funding Opportunity Number: RFA-MH-20-145 . Received Date: 2019-10-03T16:24:07.000-04:00

PROFILE - Senior/Key Person

Prefix: First Name*: CORY Middle Name T Last Name*: MILLER Suffix:

Position/Title*: Associate Professor
Organization Name*: The Regents of the Univ. of Calif., U.C. San Diego
Department: Psychology
Division:
Street1*: 9500 Gilman Dr. #0109
Street2:
City*: La Jolla
County:
State*: CA: California
Province:
Country*: USA: UNITED STATES
Zip / Postal Code*: 920930000

Phone Number*: 858-822-2247 Fax Number:

E-Mail*: corymiller@ucsd.edu

Credential, e.g., agency login: username [redacted]

Project Role*: Co-Investigator Other Project Role Category:

Degree Type: PHD,BA Degree Year: 2003,1998

Attach Biographical Sketch*: File Name: Biosketch_CoryMiller.pdf

Attach Current & Pending Support: File Name:

PROFILE - Senior/Key Person

Prefix: First Name*: Jessica Middle Name Last Name*: Izzi Suffix:

Position/Title*: Assistant Professor
Organization Name*: Johns Hopkins University
Department: SOM Comp Med Laboratory Animal
Division: School of Medicine
Street1*: 720 Rutland Ave
Street2: Ross 429
City*: Baltimore
County:
State*: MD: Maryland
Province:
Country*: USA: UNITED STATES
Zip / Postal Code*: 21205-2109

Phone Number*: (410) 955-3273 Fax Number:

E-Mail*: jizzi1@jhmi.edu

Credential, e.g., agency login:

Project Role*: Co-Investigator Other Project Role Category:

Degree Type: Degree Year:

Attach Biographical Sketch*: File Name: Biosketch_Jessica_Izzi.pdf

Attach Current & Pending Support: File Name:

PROFILE - Senior/Key Person

Prefix: First Name*: SARAH Middle Name Last Name*: BECK Suffix:

Position/Title*: Assistant Professor
Organization Name*: Johns Hopkins University
Department: Molecular and Comparative Path
Division: School of Medicine
Street1*: 733 N. Broadway, Suite 833
Street2:
City*: Baltimore
County:
State*: MD: Maryland
Province:
Country*: USA: UNITED STATES
Zip / Postal Code*: 210450000

Phone Number*: 410-955-9770 Fax Number:

E-Mail*: sbeck8@jhmi.edu

Credential, e.g., agency login: [redacted]

Project Role*: Other (Specify) Other Project Role Category: Veterinarian

Degree Type: DVM,BS Degree Year: 2002,2002

Attach Biographical Sketch*: File Name: Biosketch_Sara_Beck.pdf

Attach Current & Pending Support: File Name:

PROFILE - Senior/Key Person

Prefix: First Name*: Eric Middle Name Kenneth Last Name*: Hutchinson Suffix:

Position/Title*: Associate Director, Research Animal Res
Organization Name*: Johns Hopkins University
Department: Animal Resources
Division: School of Medicine
Street1*: 720 Rutland Ave
Street2:
City*: Baltimore
County:
State*: MD: Maryland
Province:
Country*: USA: UNITED STATES
Zip / Postal Code*: 212050000

Phone Number*: 4109553273 Fax Number:

E-Mail*: ehutchi8@jhmi.edu

Credential, e.g., agency login: [redacted]

Project Role*: Other (Specify) Other Project Role Category: Veterinarian

Degree Type: DVM,AB Degree Year: 2008,2000

Attach Biographical Sketch*: File Name: Biosketch_Eric_Hutchinson.pdf

Attach Current & Pending Support: File Name:

BIOGRAPHICAL SKETCH

Prov de the fo ow ng nformat on for the Sen or/key personne and other s gn f cant contr butors.
Fo ow th s format for each person. DO NOT EXCEED FIVE PAGES.

NAME: Wang, Xiaoqin

eRA COMMONS USER NAME (credential, e.g., agency login) [redacted]

POSITION TITLE: Professor of Biomedical Engineering and Neuroscience

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
Sichuan University, Sichuan, China	B.S.	07/1984	Electrical Engineering
University of Michigan, Ann Arbor, MI	M.S.E.	05/1986	Electrical Engineering and Computer Science
Johns Hopkins University, Baltimore, MD	Ph.D.	05/1992	Biomedical Engineering & Auditory Neurosci.
University of California, San Francisco, CA	Postdoctoral	08/1995	Cortical Neurophysiol & Neural Plasticity

A. Personal Statement

I was initially trained as an electrical engineer with a strong background in mathematics and engineering. I became interested in how the brain processes sensory information in graduate school and have pursued this passion ever since. I have studied both auditory and somatosensory systems in a variety of animal models, from rodents to non-human primates, from the periphery to the cerebral cortex in a wide range of experiments utilizing innovative experimental, computational and engineering approaches. I have tackled challenging problems in auditory neuroscience and gained considerable experience in managing parallel research projects along multiple directions. My primary research interest is to understand neural mechanisms underlying perception and production of communication sounds (speech and vocalizations) and auditory-vocal interactions. My laboratory pioneered the common marmoset (*Callithrix jacchus*) as a model system to study neural basis of hearing and vocal communication and has maintained a large breeding colony since 1995. At Johns Hopkins University, I have mentored more than 30 graduate students and postdoctoral fellows. A number of my formal trainees have become independent investigators in academic positions.

1. Wang, X., M.M. Merzenich, K. Sameshima and W.M. Jenkins. Remodeling of Hand Representation in Adult Cortex Determined by Timing of Tactile Stimulation. *Nature*, 378: 71-75 (1995).
2. Wang, X., T. Lu, R.K. Snider and L. Liang. Sustained firing in auditory cortex evoked by preferred stimuli. *Nature* 435: 341-346 (2005). PMID: 15902257
3. Bendor, D. A. and X. Wang. The neuronal representation of pitch in primate auditory cortex. *Nature* 436:1161-1165 (2005). PMID: 16121182
4. Eliades, S.J. and X. Wang. Neural Substrates of Vocalization Feedback Monitoring in Primate Auditory Cortex. *Nature* 453: 1102-1106 (2008). PMID: 18454135

B. Positions and Honors

Positions and Employment

1995-2002 Assistant Professor, Departments of Biomedical Engineering and Neuroscience, Johns Hopkins University School of Medicine

2002-2005 Associate Professor, Departments of Biomedical Engineering and Neuroscience, Johns Hopkins University School of Medicine
2005-present Professor, Departments of Biomedical Engineering, Neuroscience and Otolaryngology, Johns Hopkins University School of Medicine

Other Experience and Professional Memberships

Reviewers: *NIH AUD Study Section (2006, Regular: 2007-2011), IFCN-8 Study Section (2001), NIDCD R21 &. R03 Study Sections (1998-2000), NSF Grant Review Panelists (2001, 2005, 2009, 2010, 2015)*

Reviewers: *Science, Nature, Nature Neuroscience, PNAS, Neuron, PLoS Biology, Journal of Neuroscience, Journal of Neurophysiology, Current Biology, Neuroscience, Cerebral Cortex, Brain Research, Journal of Comparative Neurology, Behavioral Neuroscience, Journal of Acoustic Society of America, Hearing Research, Journal of Association of Research in Otolaryngology, Neural Computation, Journal of Computational Neuroscience, Annals of Neurology, IEEE Transaction on Biomedical Engineering*.

Co-organizers of "Advances and Perspectives in Auditory Neuroscience (APAN)", an annual satellite symposium at Society for Neuroscience Annual Meeting (2003-present), "Beijing International Workshop on Auditory Neuroscience" (2009, 2012), "The Common Marmoset as a Transgenic Model of the Human Brain in Health and Disease" workshop at HHMI Janelia Research Campus (2015), "Primate Neuroscience Workshop" at Tsinghua University (2015), "Primate Neuroscience: perception, cognition, and disease models" conference at Cold Spring Harbor Asia, Suzhou, China (2017)

Honors

1992 The Kleberg Foundation Postdoctoral Fellowship
1999 Presidential Early Career Award for Scientists and Engineers (PECASE)
2013 Fellow, American Institute for Medical and Biological Engineering (AIMBE)

C. Contribution to Science

1. I pioneered the marmoset model for behavioral and neurophysiological studies of auditory and vocal functions. Marmoset is an especially interesting non-human primate species for neuroscience research because of its rich social behaviors and rapid reproduction rate. The latter is an important factor in creating transgenic animal models. The marmoset has not been widely used in brain research until recently. I began to study marmosets as a postdoctoral fellow at UCSF and have made important contributions to this growing field by developing key chronic neural recording techniques in my laboratory at Johns Hopkins University since 1995. My laboratory was the first to develop both extracellular and intracellular recording techniques in awake and behaving marmosets, the first to develop wireless neural recording technique with chronically implanted multi-channel electrode arrays in freely moving marmosets. My laboratory is also the first to develop an operant conditioning technique to study marmoset's perceptual behaviors. Other laboratories that study the marmoset are now using these techniques. In addition, my laboratory has systematically studied and quantified vocal repertoire in both adult and developing marmosets. We also developed computational models to synthesize marmoset vocalizations based on their statistics. These fundamental studies have paved the way for further studies on behavioral and neural mechanisms underlying vocal communication by marmosets.

    a. Eliades, S.J. and X. Wang. Chronic multi-electrode neural recording in free-roaming monkeys. *J Neurosci Methods.* 172(2):201-214 (2008). PMID: 18572250 PMCID: PMC2553366
    b. Roy S, Wang X. Wireless multi-channel single unit recording in freely moving and vocalizing primates. *J Neurosci Methods*. 203(1): 28-40 (2012). PMID: 21933683 PMCID: PMC3848526
    c. Agamaite, J.A., Chang, C-J, Osmanski, M. S., & Wang, X. A Quantitative Acoustic Analysis of the Vocal Repertoire of the Common Marmoset (*Callithrix jacchus*). *J Acoust Soc Am* 138: 2906-2928 (2015). PMID: 26627765 PMCID: PMC4644241
    d. Pistorio, A.L., B. Vintch, and X. Wang**,** Acoustical analysis of vocal development in a New World primate, the common marmoset (*Callithrix jacchus*). *J. Acoust. Soc. Am.* 120:1655-1670 (2006). PMID: 17004487

2. I have led important discoveries of neural coding mechanisms of auditory cortex. For several decades, the majority of studies of auditory cortex were conducted in anesthetized animals. The progress of the field was relatively slow comparing with the study of the visual system. This was in part due to the fact that

auditory cortex is severely suppressed under anesthesia and neurons in this brain region are highly non-linear. Through a series of quantitative and innovative experiments in alert marmosets, my laboratory has elucidated various neural coding mechanisms by auditory cortex, in particular, how rapidly time-varying sounds are represented by firing-rate based coding schemes. We also demonstrated spectral and spectro-temporal selectivity of auditory cortex neurons. One important observation we made was that the temporal firing pattern of an auditory cortex neuron is associated with the optimality of an acoustic stimulus.

a. Lu, T., L. Liang and X. Wang. Temporal and rate representations of time-varying signals in the auditory cortex of awake primates. *Nat Neurosci*, 4:1131-1138, (2001). PMID: 11593234
b. Barbour, D. and X. Wang. Contrast tuning in auditory cortex. *Science*, 299: 1073-1075 (2003). PMID: 12586943
c. Wang, X., T. Lu, R.K. Snider and L. Liang. Sustained firing in auditory cortex evoked by preferred stimuli. *Nature* 435: 341-346 (2005). PMID: 15902257
d. Bendor, D. A. and X. Wang. Differential neural coding of acoustic flutter within primate auditory cortex. *Nat Neurosci.* 10:763-771 (2007). PMID: 17468752

3. I have led important discoveries of neural representations of pitch and harmonicity in auditory cortex. This is an important area of research in auditory neuroscience because a fundamental structure of sounds encountered in the natural environment is the harmonicity. Harmonicity is an essential component of music found in all cultures. It is also a unique feature of vocal communication sounds such as human speech and animal vocalizations. Through a series of experiments, we have identified a special “pitch center” in marmoset auditory cortex that mirrors a seminar region found in human auditory cortex by other researchers. We also showed that marmosets could perceive and discriminate pitch of harmonic complex sounds and exhibit human-like pitch perception behaviors. Together, our findings suggest that a fundamental organizational principle of auditory cortex is based on the harmonicity. Such an organization likely plays an important role in music processing by the brain. It may also form the basis of the preference for particular classes of music and voice sounds.

a. Bendor, D. A. and X. Wang. The neuronal representation of pitch in primate auditory cortex. *Nature* 436:1161-1165 (2005). PMID: 16121182
b. Osmanski M. S., Song X. and X. Wang. The role of harmonic resolvability in pitch perception in a vocal non-human primate, the common marmoset (Callithrix jacchus). *J. Neurosci.* 33: 9161-9168 (2013). PMID: 23699526 PMCID: PMC3694575
c. Wang X. The harmonic organization of auditory cortex. *Front. Syst. Neurosci.* **7**:114 (2013). doi: 10.3389/fnsys.2013.00114. PMID: 24381544 PMCID: PMC3865599
d. Song, X., Osmanski, M. S., Guo, Y., & Wang, X. Complex pitch perception mechanisms are shared by humans and a New World monkey. *Proc Natl Acad Sci U S A.* 113(3): 781-6 (2016). PMID: 26712015 PMCID: PMC4725463

4. I have led important discoveries of behavioral and neural mechanisms for vocal control and vocal feedback processing in the non-human primate brain. These studies are highly relevant for understanding speech processing mechanisms in the human brain. Until recently, the vast majority of studies on vocal production and feedback processing have been based on songbird models. The marmoset model developed in my laboratory has provided a unique opportunity to study these questions in a primate brain. We have developed behavioral techniques to induce vocal behaviors in laboratory condition and identify regions in the frontal cortex that are involved in vocal production. We have observed for the first time neural activity in auditory cortex that signals vocal feedback perturbations.

a. Eliades, S.J. and X. Wang. Sensory-motor interaction in the primate auditory cortex during self-initiated vocalizations. *J. Neurophysiology*, 89: 2194-2207 (2003). PMID: 12612021
b. Miller, C. T. and X. Wang. Sensory-motor interactions modulate a primate vocal behavior: antiphonal calling in common marmosets. *J. Comp Neurobiol. A.* 192:27-38 (2006). PMID: 16133500
c. Eliades, S.J. and X. Wang. Neural Substrates of Vocalization Feedback Monitoring in Primate Auditory Cortex. *Nature* 453: 1102-1106 (2008). PMID: 18454135

d. Roy S, Miller C, Gottsch D, and Wang X. Vocal control by common marmoset in the presence of interfering noise. *The Journal of Experimental Biology* 214: 3619-3629 (2011). PMID: 21993791 PMCID: PMC3192021

5. My laboratory has developed a cochlear implant model using the marmoset, the first of its kind in this non-human primate species. We have used this unique model to study how the auditory cortex represents CI stimulation and discovered important neural coding properties.

a. Johnson LA, Della Santina CC, Wang X. Temporal bone characterization and cochlear implant feasibility in the common marmoset (Callithrix jacchus). *Hear Res.* 290(1-2): 37-44 (2012). PMID: 22583919 PMCID: PMC3394878
b. Johnson, L.A., Della Santina, C.C., Wang, X. Selective neuronal activation by cochlear implant stimulation in auditory cortex of awake primate. *J Neurosci.* 36(49):12468-12484 (2016). PMCID: PMC5148231
c. Johnson, L.A., Della Santina, C.C., Wang, X. Representations of time-varying cochlear implant stimulation in auditory cortex of awake marmosets (Callithrix jacchus). *J Neurosci.* 37(29): 7008-7022 (2017). PMID: 28634306 PMCID: PMC5518426

D. Research Support

R01 DC03180 Xiaoqin Wang (P.I.) 1/1/2015-12/31/2019
NIH/NIDCD
Information Processing in Auditory Cortex
The overall goal of this study is to understand neural mechanisms for representing species-specific vocalizations in auditory cortex of awake marmosets and the fundamental neural mechanisms that subserve cortical representations of these biologically important sounds. No overlap with the present application.

R01 DC005808 Xiaoqin Wang (P.I.) 3/1/2018-2/28/2023
NIH/NIDCD
Auditory-Vocal Interaction Mechanisms in Primates
The overall goal of this study is to reveal behavioral and physiological mechanisms underlying auditory-vocal interactions in non-human primates using the common marmoset as the model. The specific aims of this project are to study how the vocal production system modulates neural processing in auditory cortex, and whether marmoset vocalizations exhibit experience-based plasticity. No overlap with the present application.

R01 DC014503 Xiaoqin Wang (P.I.) Charles Della Santina (Co-PI) 12/1/2015-11/30/2020
NIH/NIDCD
Cortical processing of cochlear implant signals
The long-term goal of our research is to elucidate neural coding and plasticity mechanisms underlying cortical processing of cochlear implant (CI) signals in the context of vocal communication. We have established a new CI model (the common marmoset) to pursue these questions. The results of this research will help elucidate cortical processes involved in electric hearing and provide insights for improving current cochlear implant designs. No overlap with the present application.

N66001-17-2-4008 Xiaoqin Wang (Lead P.I.) 3/2/2017-3/1/2021
DARPA
Target Neuroplasticity Training (TNT)
The overall goal of this project is to develop a peripheral nerve stimulation training program that will enhance human perceptual and language learning. Laboratories from Johns Hopkins and UCSD will perform animal experiments to understand the neurophysiological basis of VNS-induced cortical plasticity and VNS-enhanced learning and to optimize stimulation parameters to increase the rate of peripheral nerve stimulation enhanced learning. Laboratories from Johns Hopkins, UCSF, University of Iowa and University of Texas - Austin, will perform human studies to understand the neurophysiological mechanisms for plasticity and improved learning with peripheral nerve stimulation. They will also develop invasive and non-invasive peripheral nerve stimulation training protocols to enhance language perception and learning. No overlap with the present application.

T32 EB003383 Xiaoqin Wang (P.I.) 7/1/2015-6/30/2020
NIH/NIDCD
Training Program in Neuroengineering

The central mission of this training program is to produce the next generation of engineers, scientists and educators and to groom the trainees into scientific and engineering leaders. The training program selects outstanding trainees through multi-departmental recruiting efforts and an institution-wide effort to recruit under-represented minority. The training program is structured to provide introductions to select laboratories, mentors and projects, including expanded internship opportunities to industry and the medical school, provide mentoring for career development and eventual career transition. The program includes six theme areas (Neurotechnology, Neuroimaging, Computational Neuroengineering, Systems Neuroscience, Neural Tissue Engineering, and Clinical Neuroengineering) and embraced a number of additional faculty preceptors across eight departments and two divisions. No overlap with the present application.

E. Representative Former Trainees (selected from >30 graduate students and postdocs)

Postdoctoral fellows:
Ross Snider, postdoc (current position: Associate Professor, Montana State University)
Poppy Crum, postdoc (current position: Senior Principal Scientist, Head Scientist at Dolby Laboratories)
Edward Bartlett, postdoc (current position: Associate Professor, Purdue University)
Cory Miller, postdoc (current position: Associate Professor, UCSD)
Yi Zhou, postdoc (current position: Assistant Professor, Arizona State University)
Michael Osmanski, postdoc (current position: Research Associate, Johns Hopkins University)
Lixia Gao, postdoc (current position: Assistant Professor, Zhejiang University, China)

Graduate students:
Dennis Barbour, MD/PhD student (current position: Associate Professor, Washington University)
Thomas Lu, PhD student (current position: Research Scientist, UC Irvine)
Siddhartha Kadia, PhD student (current position: CEO, Evans Analytical Group)
Simil Raghavan, PhD student (current position: Program Officer, National Academy of Engineering)
Daniel Bendor, PhD student (current position: Associate Professor, University College of London, UK)
Elias Issa, PhD student (current position: Assistant Professor, Columbia University)
Srivatsun Sadagopan, PhD student (current position: Assistant Professor, University of Pittsburg)
Steven Eliades, MD/PhD student (current position: Assistant Professor, University of Pennsylvania)
Luke Johnson, PhD student (current position: Assistant Professor, University of Minnesota)
Evan Remington, PhD student (current position: postdoc, MIT)
Lei Feng, PhD student (current position: postdoc, University of Minnesota)
Xindong Song, PhD student (current position: postdoc, Johns Hopkins University)

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: Cory Miller

eRA COMMONS USER NAME (credential, e.g., agency login): [redacted]
POSITION TITLE: Associate Professor

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
University of Colorado at Boulder	BA	12/1998	Biological Anthropology, Animal Behavior
Harvard University	PhD	08/2003	Psychology: Cognition, Brain and Beahvior
Johns Hopkins University	Post-Doc	07/2009	Neurophysiology, Neuroanatomy

A. Personal Statement

My broad research interest is in the neural basis of natural behavior in primate cortex. I have over 15 years of experience working with common marmosets, as I began working with this species of nonhuman primate during my final year of graduate school in 2002. As a graduate student, I investigated the mechanisms underlying vocal communication nonhuman primates. For my post-doc, I sought to develop a natural vocal behavior in common marmosets, known as antiphonal calling conversations, as a neural model for sensory recognition and motor control in nonhuman primates. Since starting my own laboratory at UCSD, we have continued the neurobiological and behavioral studies of antiphonal conversations have continued, as well as expanded our work to studies of the visual system and spatial navigation. We have also established a field site in Brazil to study marmosets in their natural habitat. My laboratory has also developed several cutting-edge methodological techniques for marmosets, including awake fMRI, 2-Photon Calcium imaging and optogenetic preparations. Furthermore, we have developed several conditioned behavioral paradigms to complement our studies of natural behavior in the marmosets. Overall, I have extensive expertise with numerous surgical techniques, multiple neurophysiological recording methods in awake behaving marmosets, neuroimaging and molecular technologies, as well as extensive expertise with marmoset behavior. Moreover, my laboratory has been successfully breeding marmosets since 2010 and can readily expand our existing breeding facility to meet the needs of the rapidly expanding marmoset community. My expertise is uniquely suited for successful completion of this proposal.

B. Positions and Honors

Positions

2009 - 2016 Assistant Professor, Dept of Psychology, University of California, San Diego
2016 - present Associate Professor, Dept of Psychology, University of California, San Diego

Honors and Awards

1998 - C.M.U. Young Scientist Travel Fellowship
1999 - NSF Graduate Fellowship - *Honorable Mention*
2001 - Harvard University Certificate of Distinguished Teaching
2001 – NIH NIMH Individual Pre-Doctoral NRSA Fellowship (F31 MH63501)
2002 - Harvard University Certificate of Distinguished Teaching

2004 - NIH NIDCD Individual Post-Doctoral NRSA Fellowship (F32 DC007022)

C. Contributions to Science

1. My earliest research focused on questions of auditory perception and cognition in nonhuman primates, focusing on tamarin monkeys. This line of research was performed during graduate school and aimed to utilize aspects of the species natural behavior to examine questions of recognition and categorization. This work was supported by a NIH Pre-Doctoral NRSA Fellowship.
    a. Miller, CT; Iguina, C; Hauser, MD. 2005. Processing vocal signals for recognition during antiphonal calling. *Animal Behaviour,* 69, 1387-1398.
    b. Miller, CT; Scarl, JS, Hauser, MD. 2004. Sex-specific sensory biases underlie sex differences in tamarin long call structure. *Animal Behaviour,* 68, 713-720.
    c. Miller, CT; Hauser, MD. 2004. Multiple acoustic cues underlie vocal signal recognition in tamarins: antiphonal calling experiments. *Journal of Comparative Physiology, A.*, 190, 7-19. [PMID: 14610683]
    d. Miller, CT; Dibble, E; Hauser, MD. 2001. Amodal completion of acoustic signals by a nonhuman primate. *Nature Neuroscience*, 4, 783-784.
2. Over the past several years, I developed the marmoset antiphonal calling as a model system for examining the neural basis of communication in primate cortex. At the onset of this project, relatively little was known about the behavior in marmosets and its underlying neural mechanisms. As such, it was necessary to characterize the behavior. In addition to ethological studies, we also developed novel interactive playback software that allowed us to directly engage subjects in their natural vocal interactions while maintaining experimental control. Building on this work, we examine the functional neuroanatomy of this behavior by examining Immediate Early Gene expression during this behavior. This work was initiated as a Post-Doc and was supported by a NIH Post-Doctoral NRSA Fellowship and a NIH K99 award. Since beginning my own laboratory at UCSD, we have continued this line of work to include more extensive studies of the behavior, in both the lab and at our field site in Brazil. Neurophysiological studies in freely-moving marmosets have focusing on neural activity during both vocal signal recognition and vocal production are currently in review. This work is currently supported by a NIH R01 grant (PI) and a DARPA grant (Co-PI)
    a. Casselli, C; Ayres, PHB; Castro, S; Souto, A; Schiel, N. & Miller CT. 2018. The role of extra-group encounters in a Neotropical cooperative breeding primate, common marmosets: A field playback experiment. *Animal Behaviour,* 136, 137-146
    b. Nummela, SU; Jovanovic, V.; de la Mothe, L. & Miller, CT. *2017*. Social context-dependent activity in marmoset frontal cortex populations during natural conversations. *Journal of Neuroscience,* 37, 7036-7047.
    c. Toarmino, C; Wong, L. & Miller, CT. 2017. Audience affects decision-making in a marmoset communication network. *Biology Letters,* 13, 20160934
    d. Miller, CT; Thomas, AW; Nummela, SU & de la Mothe, L. 2015. Responses of primate frontal cortex neurons during natural vocal communication. *Journal of Neurophysiology,* 114, 1158-1171.
3. My laboratory is now pursuing experiments to examine the neural circuitry underlying perception and cognition in common marmosets. To this end, we developed new experimental paradigms for marmosets to perform conditioned visual behavioral tasks. We also developed a fMRI preparation for awake marmosets to examine the areas of the marmoset brain support specific perceptual and cognitive processes. Furthermore, we developed an optogenetic photostimulation preparation for marmosets to examine the functional circuitry underlying functional circuitry and a 2-Photon calcium imaging preparation to investigate population dynamics of perceptual and cognitive processes. We are now leveraging this powerful technological tool kit to examine the neural basis of memory and spatial navigation in marmoset hippocampus. The hippocampus experiments are currently supported by a NIH R01 grant (PI).
    a. Nummela, SU; Jutris, M; Wixted, J; Buffalo, E & Miller, CT. *2019*. Recognition memory in marmoset and macaque monkeys: a comparison of active vision. *Journal of Cognitive Neuroscience,* 31, 1318-1328.
    b. Toarmino, C.; Yen, C.; Papoti, D; Bock, N.A.; Leopold, D.; Miller, CT* & Silva, A*. 2017. Functional magnetic resonance imaging of auditory cortical fields in awake marmosets. *Neuroimage*, 162, 86-92. **Equal Contributions*

c. MacDougall, M; Nummela, S; Coop, S; Disney, A; Mitchell, JF & Miller, CT. 2016. Optogenetic manipulation of neural circuits in awake marmosets. *Journal of Neurophysiology*, 116, 1286-1294
d. Mitchell, J; Reynolds, J & Miller, CT. 2014. Active vision in marmosets: A model for visual neuroscience. *Journal of Neuroscience,* 34,1183-1194.

Complete list of my Published work in My Bibliography:
http://www.ncbi.nlm.nih.gov/myncbi/browse/collection/40791275/?sort=date&direction=ascending

D. Research Support

Ongoing Research Support

NIDCD R01 2R01 DC012097

07/01/2012-06/30/2023

Neural basis of vocal signal recognition during natural communication.
The aim of this grant is to explore the neural basis of vocal communication in primate neocortex. We combine single-neuron recordings in freely moving marmosets with interactive playback software to effectively engage subjects in their natural communication behaviors while simultaneously recording the related neural activity. Our aim here is to examine the behavioral and neural basis of vocal signal recognition and categorization. No overlap with the present application.
Role: PI

NINDS R01 NS109294

12/01/2018-11/30/2023

Neural Basis of Memory in Primate Medial Temporal Lobe.
The aim of this grant is to examine the role of primate hippocampus in encoding episodic memory and spatial navigation. We will characterize the responses of single neurons in primate hippocampus while marmoset monkeys perform an episodic memory task similar to approaches used in humans, as well as while the same animals explore environments to test whether the same populations support each of these cognitive processes. No overlap with the present application.
Role - PI

2019-2022 – AFOSR 19RT0316

7/1/2019-6/30/22

Visually-guided primate predation: A computational neuroethology of visual search and targeting in a complex, natural environment
The aim of this grant is to examine the role of different visual fields in marmoset cortex during active visual behavior. My part in this grant is first to develop a natural, prey-pursuit paradigm in marmosets in order to computationally characterize the individual and composite properties of this behavior. The second component of my role in this grant is to record the activity of multiple areas of marmoset cortex while animals perform this behavior using a novel whole-cortex ECoG recording approach. No overlap with the present application.
Role. Co-PI [PI: Alex Huk]

Completed Research Support

NIDCD K99/R00 DC009007

08/01/2007-07/31/2012

Cortical mechanisms underlying vocal signal recognition
The goal of this project was to employ the antiphonal calling paradigm to examine vocal signal recognition for call type. Experiments combine neurophysiology and natural vocal behaviors. The mentor for the mentored portion of this award was Xiaoqin Wang.
Role: PI

NIMH R21 MH104756

07/01/2014-06/30/2016

Optogenetic tools to distinguish neuronal class in behaving nonhuman primates.
The aim of this grant is to develop a to establish new techniques to identify the class and laminar location of neurons in visual cortex using combinations of physiological and optogenetic methods. These will also establish the methods in behaving marmosets, a small bodied New World monkey that offers many opportunities for the kinds of genetic manipulation that have been successful with mice.
Role: Co-PI

NSF IDBR 1254309 05/01/2013-04/30/2016

A measurement system for behavioral and acoustic communication networks in wild vertebrates.
The aim of this grant is to develop a novel collar based recording system that enables the acquisition of multiple data types simultaneously (i.e. vocalizations, ambient sound, spatial position, velocity, height). The goal is to place collars on all animals in a social group in order to quantify their ongoing communication networks. These collars are being developed for use with wild marmosets at the Tapacura Ecological Field Station (Recife, Brazil).
Role: Co-PI

DARPA SSC-5029

03/02/2017-07/30/2019

Targeted Neuroplasticity Training
The aim of this grant is to examine the mechanisms supporting plasticity from peripheral nerve stimulation at different levels of the auditory system. Our component of this project investigates how vagus nerve stimulation affects aspects of social learning during natural communication and how circuits in the auditory cortical system reflect these changes in behavior.
Role: Co-PI

BIOGRAPHICAL SKETCH

Prov de the fo ow ng nformat on for the Sen or/key personne and other s gn f cant contr butors.
Fo ow th s format for each person. **DO NOT EXCEED FIVE PAGES.**

NAME: Jessica Izzi, DVM, MLAS, DACLAM

eRA COMMONS USER NAME (credential, e.g., agency login) [redacted]

POSITION TITLE: Assistant Professor, Director of Large Animal Medicine and Surgery

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
Providence College	BS	5/2005	Biology
Drexel University College of Medicine	MLAS	8/2007	Lab animal medicine
Tufts Cummings School of Veterinary Medicine	DVM	5/2013	Veterinary medicine
Johns Hopkins University School of Medicine	Postdoctoral	1/2016	Lab animal medicine

A. PERSONAL STATEMENT

I have been active in the field of laboratory animal science and medicine for 14 years, having conducted and supported research projects throughout my career. My primary interests lie in assessment and refinement of clinical and surgical management strategies for animals used in biomedical research, especially nonhuman primates and other large animal models, as well as protocol and animal-model development. I have 5 years of experience providing veterinary support to breeding colonies of common marmosets as well as marmosets used in biomedical research, including diagnosis and treatment of common disease states, performing major and minor surgical procedures, determining anesthetic regimens for complex surgical procedures, and management of breeding and social housing concerns. I am recognized as an expert in the clinical care of marmosets, and was invited to lecture on “Clinical Concerns in the Common Marmoset” at the 2018 ILAR Roundtable Workshop on “Care, Use and Welfare of Marmosets as Animal Models for Gene Editing-based Biomedical Research”. As assistant surgeon in one of the largest intramural laboratory animal programs at the NIH, I gained significant surgical experience performing advanced procedures in non-human primates, including orthopedic and neurosurgery. There, I functioned as one of two referral surgeons for a variety of clinical surgical and diagnostic procedures in support of all animal colonies housed within the Division of Veterinary Resources, in addition to performing research-related procedures. Later, having now rejoined the faculty at Johns Hopkins, I serve as the Director of Large Animal Medicine and Surgery and collaborate with numerous researchers on clinical and surgical animal models. Currently, I serve as the primary veterinarian for the marmoset breeding colony at Johns Hopkins University and as co-PI on a project with Drs. Xiaoqin Wang and James Segars for the production of transgenic marmosets.

B. POSITIONS AND HONORS

Positions and Employment

2005-2007 Research Technician, Department of Neurobiology and Anatomy, Drexel University College of Medicine, Philadelphia, PA

2007-2009 Surgery and Veterinary Technician, Division of Comparative Medicine, Massachusetts Institute of Technology, Cambridge, MA

2010-2011	Veterinary Student Technician, Emergency and Critical Care, Foster Hospital for Small Animals, North Grafton, MA
2011-2011	Veterinary Student Extern, Laboratory Animal Services, Novartis Institutes for Biomedical Research, Cambridge, MA
2013-2014	Contract Veterinary Surgeon, Baltimore Animal Rescue and Care Shelter, Baltimore, MD
2016-2018	Assistant Surgeon and Clinical Veterinarian, Division of Veterinary Resources, Sobran, Inc., National Institutes of Health, Bethesda, MD
2018-Present	Director of Large Animal Medicine and Surgery, Assistant Professor, Department of Molecular and Comparative Pathobiology, Johns Hopkins University, Baltimore, MD

Honors

2006 DVB-AALAS J.J. Noonan Scholarship
2012 American College of Laboratory Animal Medicine (ACLAM) Externship Award
2014 Association of Primate Veterinarians (APV) Travel Grant

C. CONTRIBUTIONS TO SCIENCE

Sandrow-Feinberg HR, **Izzi J**, Shumsky JS, Zhukareva V, Houle JD. Forced Exercise as a Rehabilitation Strategy after Unilateral Cervical Spinal Cord Contusion Injury. J Neurotrauma. 2009 May; 26(5): 721-731. doi: 10.1089/neu.2008.0750. PubMed PMID: 19489718; PubMed Central PMCID: PMC2848827.

Muth DC, McAlexander MA, Ostrenga LJ, Pate NM, **Izzi JM**, Adams RJ, Metcalf-Pate KA, Beck SE, Karim BO, Witwer KW. Potential role of cervicovaginal extracellular particles in diagnosis of endometriosis. BMC Vet Res. 2015 Aug; 11: 187. doi: 10.1186/s12917-015-0513-7. PubMed PMID: 26253321; PubMed Central PMCID: PMC4529722.

Izzi JM, Beck SE, Adams RJ, Metcalf-Pate KA, Hutchinson EK. Serum Cobalamin (Vitamin B12) Concentrations in Rhesus (*Macaca mulatta*) and Pigtailed (*Macaca nemestrina*) Macaques with Chronic Idiopathic Diarrhea. Comp Med. 2016 Aug; 66(4): 324-332. PubMed PMID: 27538863; PubMed Central PMCID: PMC4983174.

pending publication [redacted] (In Press, [redacted]

Complete List of Published Work in MyBibliography:
https://www.ncbi.nlm.nih.gov/myncbi/browse/collection/54407717/?sort=date&direction=ascending

D. Research Support

private support [redacted] 6/15/2019-12/15/2020

The Use of Midazolam as an Appetite Stimulant and Anxiolytic in the Common Marmoset

N66001-17-2-4008 (P.I. Xiaoqin Wang) 3/2/2017-3/1/2021
DARPA
Target Neuroplasticity Training (TNT)

The overall goal of this project is to develop a peripheral nerve stimulation training program that will enhance human perceptual and language learning. Laboratories from Johns Hopkins and UCSD will perform animal experiments to understand the neurophysiological basis of VNS-induced cortical plasticity and VNS-enhanced learning and to optimize stimulation parameters to increase the rate of peripheral nerve stimulation enhanced learning. Laboratories from Johns Hopkins, UCSF, University of Iowa and University of Texas - Austin, will perform human studies to understand the neurophysiological mechanisms for plasticity and improved learning with peripheral nerve stimulation. They will also develop invasive and non-invasive peripheral nerve stimulation training protocols to enhance language perception and learning.

BIOGRAPHICAL SKETCH

NAME: Sarah E. Beck

eRA COMMONS USER NAME: [redacted]

POSITION TITLE: Assistant Professor, Johns Hopkins School of Medicine

EDUCATION/TRAINING

INSTITUTION AND LOCATION	DEGREE	Completion Date MM/YYYY	FIELD OF STUDY
University of Maryland, College Park, MD	BS	5/2002	Marine Biology
Virginia-Maryland Regional College of Veterinary Medicine, Blacksburg, VA	DVM	5/2007	Veterinary Medicine
Johns Hopkins University, Baltimore, MD	Fellowship	7/2012	Comparative Pathology
Johns Hopkins University, Baltimore, MD	PhD	5/2014	Molecular Biology
Johns Hopkins University, Baltimore, MD	Post-doc	1/2015	Virology

A. Personal Statement

As a veterinarian boarded in veterinary anatomic pathology, I have extensive expertise in infectious disease pathology as well as exposure to a wide variety of laboratory animal models. This includes over eight years of experience interpreting histopathology from numerous animal models of both infectious and neoplastic disease processes using many different species, including (but not limited to): mice, rats, pigtailed and rhesus macaques, rabbits, guinea pigs, chinchillas, New World primates such as marmosets and owl monkeys, African clawed frogs, and zebrafish. This work has included scoring histopathologic lesions on H&E slides, performing necropsies on study animals, performing and interpreting immunohistochemistry, and interpreting immunofluorescence and in situ hybridization assays.

Although I have worked with a variety of species, non-human primate modeling of infectious disease and pathology is my main specialty. I have been doing pathology on SIV-infected rhesus and pigtailed macaques since 2009. My work for the retrovirus lab includes but is not limited to scoring histopathologic lesions on H&E slides, performing necropsies on all study animals, performing and interpreting immunohistochemistry, and interpreting immunofluorescence and in situ hybridization assays. As a junior faculty member in the retrovirus lab at Johns Hopkins University, my research interests are in the field of viral immunology; in particular, MHC class I/T cell-mediated control of viral replication.

B. Positions and Honors

Professional Experience:

2002-2003:	Molecular biologist; Virion Systems, Rockville, MD
May-August 2004:	Junior COSTEP; NIH Animal Center, Poolesville, MD
May-August 2005:	Junior COSTEP; NIH, Bethesda, MD
2007-2008:	Associate Veterinarian; Aberdeen Veterinary Clinic, Aberdeen, MD
2008-2012:	Postdoctoral fellow, veterinary pathology; Department of Molecular and Comparative Pathobiology, Johns Hopkins School of Medicine, Baltimore, MD

2009-2014:	Graduate student (PhD candidate); Department of Cellular and Molecular Medicine, Johns Hopkins School of Medicine, Baltimore, MD
2014-2015:	Postdoctoral Fellow, PI: Joseph Mankowski
2015-2016:	Instructor, Johns Hopkins School of Medicine, Baltimore, MD
2016-current:	Assistant Professor, Johns Hopkins School of Medicine, Baltimore, MD

Professional Memberships:

2003-2007:	Student member of the Virginia Veterinary Medical Association
2003-2007:	Member of the Public Veterinary Practice Club
2003-2007:	Member of the Student Chapter of the American Veterinary Medical Association
2005-2006:	Public/Corporate Liaison officer for the Public Veterinary Practice Club
2007-2009:	Member of the American Veterinary Medical Association
2007-current:	Member of the Maryland Veterinary Medical Association
2014-current:	Member of the American College of Veterinary Pathologists (ACVP)

Awards and Honors:

2002:	Golden Key International Honour Society
2000-2002:	Howard Hughes Research Fellowship
2002:	Honors Citation in Biology, University of MD, College Park
2007:	Phi Zeta chapter of the VMRCVM (for being in the top 25% of the class)
2007:	Salisbury Award in Veterinary Medicine
2008-2012	Awarded the T32 funded comparative pathology fellowship at Johns Hopkins University
2012:	Graduate student/resident ACVP Travel Award
2012:	Intersociety Council for Pathology Information, Inc. Trainee Travel Award
2013:	Young Investigator Award, 20th Conference on Retroviruses and Opportunistic Infections
2014:	C.L. Davis Foundation Student Scholarship Award

C. Contribution to Science

1. Most recently, I was co-first author on a manuscript accepted in the *American Journal of Pathology* describing an unusual, distinct lymphocyte-rich pattern of meningoencephalitis in treated, SIV-infected pigtailed macaques that bears some similarities to immune reconstitution syndrome in HIV/AIDS patients. I recently authored an invited review with my K01 co-mentor Joseph Mankowski describing our SIV macaque model of HIV-associated neurocognitive disorders, which has been published in the *Journal of NeuroVirology*. Also in the *Journal of NeuroVirology,* I published a manuscript describing the efficacy of a Gag epitope-specific virus like protein (VLP) platform based therapeutic vaccine in reducing CSF, but not plasma, viral load in SIV infected pigtailed macaques. It is this VLP platform that forms the foundation of my current research, in which we are stimulating HIV Gag T cell immune pressure in primary infection using HIV-infected humanized mice. In 2015, I authored two additional first author publications, both of which addressed the influence of host genetics on the development of lentiviral-associated central nervous system (CNS) disease, specifically SIV encephalitis (SIVE), in primate models of HIV/SIV infection. In particular, I have extensively worked with the well-established dual inoculated (SIV/B670 and SIV/17E-Fr) macaque model of SIVE originally established by MC Zink and JE Clements in the Retrovirus lab at Johns Hopkins University, the group with whom I work. Within this framework, I have contributed two major findings to the field of lentiviral pathogenesis. 1) I have shown consistent species-specific differences in SIV disease progression between rhesus and pigtailed macaques. In general, pigtailed macaques have higher plasma and cerebrospinal fluid (CSF) viral load, progress more rapidly to AIDS, and are more likely to progress to SIVE compared to rhesus macaques. 2) I have shown the importance of MHC class I allele expression in progression to SIVE. We identified neuroprotective MHC class I alleles in both pigtailed and rhesus macaques (Mamu-A*001 in rhesus macaques and Mane-A1*084:01:01 in pigtailed macaques). Animals

expressing these alleles are less likely to develop SIV encephalitis and have lower viral replication in the brain, demonstrating that cell mediated immune responses are critical to SIV CNS disease progression.

a. Mangus LM*, **SE Beck***, Queen SE, Brill SA, Shirk EN, Metcalf Pate KA, Muth DC, Adams RJ, Gama L, Clements JE, Mankowski JL. Lymphocyte-dominant encephalitis and meningitis in Simian Immunodeficiency Virus-infected macaques receiving antiretroviral therapy. *The American Journal of Pathology*. 2018; 188(1). PMID: 29229308.
*__both authors contributed equally__

b. **Beck SE**, Queen SE, Metcalf Pate KA, Mangus LM, Abreu CM, Gama L, Witwer KW, Adams RJ, Zink MC, Clements JE, Mankowski JL. An SIV/macaque model targeted to study HIV-associated neurocognitive disorders. *Journal of NeuroVirology*, 2017 Oct 3; doi: 10.1007/s13365-017-0582-4. [Epub ahead of print]. PMID: 28975505.

c. **Beck SE**, Queen SE, Viscidi R, Johnson D, Kent SJ, Adams RJ, Tarwater PM, Mankowski JL. Central nervous system-specific consequences of simian immunodeficiency virus Gag escape from major histocompatibility complex class I-mediated control. *Journal of NeuroVirology*, 2016; 22(4): 498-507. PMID: 26727909.

d. **Beck SE**, Kelly KM, Queen SE, Adams RJ, Zink MC, Tarwater PM, Mankowski JL. Macaque Species Susceptibility to Simian Immunodeficiency Virus: Increased Incidence of SIV Central Nervous System Disease in Pigtailed Macaques Versus Rhesus Macaques. *Journal of NeuroVirology*, 2015; 759:303-12. PMID: 25672885.

2. I have also extensively contributed in a collaborative role both within the Retrovirus group at Johns Hopkins University and outside of the Retrovirus group. My predominant role for most of these projects was in providing expertise in SIV-associated pathology in an animal model or general veterinary pathology expertise. For many of these studies, I not only performed postmortem examinations and interpreted histopathologic lesions, but also provided guidance in lesion interpretation and manuscript preparation.

a. Pohlmeyer CW, Laskey SB, **Beck SE**, Xu DC, Capoferri AA, Garliss CC, May ME, Livingston A, Lichmira W, Moore RD, Leffell MS, Butler NJ, Thorne JE, Flynn JA, Siliciano RF,5, Blankson JN. Cross-reactive microbial peptides can modulate HIV-specific CD8+ T cell responses. PLos One. 2018; 13(2). PMID: 29466365.

b. Rao AD, Shin EJ, **Beck SE**, Garrett C, Kim SH, Lee NJ, Liapi E, Wong J, Herman J, Narang A, Ding K. Demonstration of Safety and Feasibility of Hydrogel Marking of the Pancreas-Duodenum Interface for Image Guided Radiation Therapy (IGRT) in a Porcine Model: Implications in IGRT for Pancreatic Cancer Patients. International journal of radiation oncology, biology, physics. 2018; 101(3):640-645. PMID: 29680252

c. Coleman CM, Sisk JM, Halasz G, Zhong J, **Beck SE**, Matthews KL, Venkataraman T, Rajagopalan S, Kyratsous CA, Frieman MB. CD8+ T cells and Macrophages Regulate Pathogenesis in a Mouse Model of MERS-CoV Disease. *J Virol*. 2017; 91(1) PMID: 27795435.

d. Feng N, Huke S, Zhu Guangshuo, Tocchetti CG, Shi S, Aiba T, Kaludercic N, Hoover DB, **Beck SE**, Mankowski JL, Tomaselli GF, Bers DM, Kass DA, Paolocci N. Constitutive BDNF/TrkB signaling is required for normal cardiac contraction and relaxation. *PNAS*. 2015. Feb 10;112(6): 1880-5. PMID: 25583515.

Complete List of Published Work in My Bibliography:

https://www.ncbi.nlm.nih.gov/sites/myncbi/sarah.beck.1/bibliography/41334803/public/?sort=date&direction=ascending

D. Research Support

Ongoing Research Support

K01OD021323 Beck (PI) 08/04/2016 – 07/31/2021
Virus like particles as a therapeutic vaccine for HIV
The first goal of this mentored research study is to stimulate broad HIV Gag-specific cytotoxic T cells using a virus like protein platform to induce effective T cell-mediated killing of HIV-infected cells in primary infection and overall reduction of the viral reservoir in HIV-infected humanized mice. The second goal is to provide the mentorship, support, and protected time necessary for me to progress into a successful and productive career in independent translational research in the field of vaccine immunology under the mentorship of Dr. Joel Blankson.
Role: PI

P01AI31306 (PI – J Clements) 06/23/2017 – 05/31/2022
NIH NIAID
Modeling HIV rebound: role of SIVmac251 functional reservoirs and biomarkers of reactivation
Includes the measurement of residual SIV in the peripheral blood and tissues in the SIV-infected macaque model of HIV latency by both QVOA and MVOA.
Role: Co-I

Completed Research Support

2T32RR007002-35 Zink (PI) 07/01/2010 - 06/30/2015
Training Veterinarians for Careers in Biomedical Research
The primary objective of this T32 training grant is to train veterinarians for careers in biomedical research; this grant provided funding for my entire graduate-level research career at Johns Hopkins University as well as to learn both diagnostic pathology in the context of biomedical research, allowing me to become boarded in the American College of Veterinary Pathology.
Role: PhD Candidate / Graduate Student

BIOGRAPHICAL SKETCH

Prov de the fo ow ng nformat on for the Sen or/key personne and other s gn f cant contr butors.
Fo ow th s format for each person. **DO NOT EXCEED FIVE PAGES.**

NAME: Eric Hutchinson, DVM, DACLAM

eRA COMMONS USER NAME (credential, e.g., agency login): [redacted]

POSITION TITLE: Attending Veterinarian, Director of Research Animal Resources, Assistant Professor

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
Georgetown University	BA	5/2000	English, psychology
Colorado State University	Certificate	5/2006	Business for veterinary health professionals
Colorado State University	DVM	5/2008	Veterinary medicine
Johns Hopkins University School of Medicine	Fellowship	7/2011	Lab animal medicine

A. PERSONAL STATEMENT

I have been active in the field of laboratory animal science and medicine for 20 years, having conducted and supported research projects throughout my career. My primary interests lie in the assessment, prevention, and treatment of abnormal behaviors in rodents, nonhuman primates and other animals used in biomedical research, but I have also been a collaborator and primary researcher on a number of clinically oriented research projects. In veterinary school I evaluated the effects of different rearing settings on the physiological and behavior reactions of mice to various environmental enrichments. As a post-doctoral fellow at Johns Hopkins, I became experienced in a variety of technical and surgical procedures with many species, including phlebotomy, lymph-node and gastrointestinal biopsy, collection of CSF, etc. As faculty I have directed ongoing research into new techniques for diagnosing wasting disease in marmosets. I have also led research projects examining the cognitive alterations resulting from inadequate socialization of macaques, demonstrating the efficacy of guanfacine in treating the aberrant behaviors, and examining the effects of anti-parasitic treatments in our mouse colonies. At the NIH, I directed the behavioral management program at one of the largest intramural laboratory animal programs in the Division of Veterinary Resources. There I helped set policy regarding animal enrichments and socialization, consulted for intramural and extramural programs regarding behavioral management issues, and managed the care of animals with behavioral abnormalities. In this position, I built a reputation as one of the field's experts in the pharmacological treatment of behavioral abnormalities in nonhuman primates. Having now rejoined the faculty at Johns Hopkins, I serve as the Attending Veterinarian and Director of Research Animal Resources, am the primary faculty veterinarian for our primate breeding facility, as well as direct veterinary clinical research into drug therapies as tools for behavioral management.

B. POSITIONS AND HONORS

Positions and Employment

2000 - 2001 Environmental Enrichment Technician, NICHD, NIH, Poolesville, MD
2001 - 2004 Behaviorist, Division of Veterinary Resources, NIH, Bethesda, MD
2005 - 2008 Environmental Enrichment Consultant, Fort Collins, CO
2011 - 2014 Attending Veterinarian, Edgewood Chemical Biological Center, Edgewood, MD

2011 - 2014	Director of Primate Medicine, Research Animal Resources, Assistant Professor, Department of Molecular and Comparative Pathobiology, Johns Hopkins University, Baltimore, MD
2014 - 2016	Veterinary Behaviorist, Division of Veterinary Resources, Bethesda, MD
2016 – 2019	Associate Director of Research Animal Resources, Johns Hopkins University, Baltimore, MD
2019-Present	Attending Veterinarian, Director of Research Animal Resources, Assistant Professor, Department of Molecular and Comparative Pathobiology, Johns Hopkins University, Baltimore, MD

Honors

2003	National Institutes of Health Merit Award
2005	American Society for Laboratory Animal Practitioners Student Award

C. CONTRIBUTIONS TO SCIENCE

1. Diagnosing and Treating Common Disease States in Marmosets and other Nonhuman Primates

Baxter VK, Shaw GC, Sotuyo NP, Carlson CS, Olson EJ, Zink MC, Mankowski JL, Adams RJ, **Hutchinson EK**, Metcalf Pate KA. Serum albumin and body weight as biomarkers for the antemortem identification of bone and gastrointestinal disease in the common marmoset. PLoS One. 2013 Dec 6;8(12). PubMed PMID: 24324827; PubMed Central PMCID: PMC3855796

Otovic P, Smith S, **Hutchinson E**. The use of glucocorticoids in marmoset wasting syndrome. J Med Primatol. 2015 Apr;44(2):53-9. PMID: 25614344

Olson EJ, Shaw GC, Hutchinson EK, Schultz-Darken N, Bolton ID, Parker JB, Morrison JM, Baxter VK, Pate KA, Mankowski JL, Carlson CS. Bone Disease in the Common Marmoset: Radiographic and Histological Findings. Vet Pathol. 2015 Sep;52(5):883-93. doi: 10.1177/0300985815589354. Epub 2015 Jun 15. PubMed PMID: 26077785.

pending publication [redacted] Accepted [redacted]

2. Multifaceted Treatment of SIB and Other Abnormal Behaviors in Nonhuman Primates

Freeman ZF, Rice KA, Soto PL, Metcalf Pate KA, Weed MR, Ator NA, DeLeon IG, Wong DF, Zhou Y, Mankowski JL, Zink MC, Adams RJ, **Hutchinson EK**. Neurocognitive Dysfunction and Pharmacologic Intervention Using Guanfacine in a Rhesus Macaque Model of Self-Injurious Behavior. Transl Psychiatry. 2015 May 19;5:e567. PMID: 25989141 PMCID: PMC4471292

Freeman ZT, Krall C, Rice KA, Adams RJ, Metcalf Pate KA, **Hutchinson EK**. Severity and Distribution of Wounds in Rhesus Macaques (Macaca mulatta) Correlate with Observed Self-Injurious Behavior. J Am Assoc Lab Anim Sci. 2015 Sep;54(5):516-20. PMID: 26424249

Bloomsmith MA, Perlman J, **Hutchinson EK**, Sharpless M. "Behavioral Management Programs to Promote Laboratory Animal Welfare." *Management of Animal Care and Use Programs in Research, Teaching, and Testing, Second Edition*. Ed. Mark A. Suckow, Fred A. Douglas, Robert H. Weichbrod. CRC Press, Boca Raton, FL. 2017.

Hutchinson EK. "Interactions with Veterinary Medicine." *Handbook of Primate Behavioral Management*. Ed. Stephen Schapiro. CRC Press, Boca Raton, FL. 2017.

3. The Effects of Common Management Variables on Mouse Behavior

Hutchinson E, Avery A, VandeWoude S. 2005 Mar. Environmental Enrichment for Laboratory Rodents. ILAR J. 2005;46(2):148-61. Review. PubMed PMID: 15775024

Gadad BS, Daher JP, **Hutchinson EK**, Brayton CF, Dawson TM, Pletnikov MV, Watson J. Effect of Fenbendazole on Three Behavioral Tests in Male C57BL/6N Mice. J Am Assoc Lab Anim Sci. 2010;49(6):821-5. PubMed PMID: 21205447; PubMed Central PMCID: PMC2994049.

Hutchinson E, Avery A, VandeWoude S. Environmental Enrichment During Rearing Impacts Corticosterone Levels, Thymocyte Numbers, and Aggression in Female BALB/c Mice. J Am Assoc Lab Anim Sci. 2012;51(1):18-24. PubMed PMID: 22330863. PubMed Central PMCID: PMC3276961

Complete List of Published Work in MyBibliography:

https://www.ncbi.nlm.nih.gov/sites/myncbi/16gzm9ank_SQv/bibliography/40305147/public/?sort=date&direction=ascending

D. RESEARCH SUPPORT

R01 MH107197 8/5/15-5/31/23
NIH/NIMH
PET Imaging of Alpha 7 and Alpha4beta2-NACHR in Schizophrenia: Cognitive Relationships

U42 OD0131117 7/1/17-6/30/21
NIH/OD
Development of an SPF *Macaca nemestrina* Breeding Colony

P40 OD013117 (Adams) 9/21/06-7/31/17
NIH/NCRR
Development of an SPF *Macaca nemestrina* Breeding Colony

R25 RR032012 (Adams) 12/1/11-11/30/14
Research Education Program for Laboratory Animal Veterinarians at Johns Hopkins University
The goal of this grant is to prepare veterinarians for scientific careers in laboratory animal medicine in

OMB Number: 4040-0001
Expiration Date: 10/31/2019

RESEARCH & RELATED BUDGET - SECTION A & B, Budget Period 1

ORGANIZATIONAL DUNS*: 0019107770000

Budget Type*: ● Project ❍ Subaward/Consortium

Enter name of Organization: JOHNS HOPKINS UNIVERSITY

Start Date*: 07-01-2020 **End Date*:** 06-30-2021 **Budget Period: 1**

A. Senior/Key Person

	Prefix	First Name*	Middle Name	Last Name*	Suffix	Project Role*	Base Salary ($)	Calendar Months	Academic Months	Summer Months	Requested Salary ($)*	Fringe Benefits ($)*	Funds Requested ($)*
1 .		Xiaoqin		Wang		PD/PI	[redacted]				19,230.00	6,442.00	25,672.00
2 .		Jessica		Izzi		Co-Investigator					59,670.00	19,989.00	79,659.00

base salary & percent effort

Total Funds Requested for all Senior Key Persons in the attached file

Additional Senior Key Persons: File Name:

Total Senior/Key Person **105,331.00**

B. Other Personnel

Number of Personnel*	Project Role*	Calendar Months	Academic Months	Summer Months	Requested Salary ($)*	Fringe Benefits*	Funds Requested ($)*
	Post Doctoral Associates						
	Graduate Students						
	Undergraduate Students						
	Secretarial/Clerical						
2	Veternarian	[redacted]			13,665.00	4,578.00	18,243.00
1	Colony Manager				59,000.00	19,765.00	78,765.00
3	**Total Number Other Personnel**					**Total Other Personnel**	**97,008.00**
						Total Salary, Wages and Fringe Benefits (A+B)	**202,339.00**

percent effort

RESEARCH & RELATED Budget {A-B} (Funds Requested)

Funding Opportunity Number: RFA-MH-20-145 . Received Date: 2019-10-03T16:24:07.000-04:00

RESEARCH & RELATED BUDGET - SECTION C, D, & E, Budget Period 1

ORGANIZATIONAL DUNS*: 0019107770000
Budget Type*: ● Project ❍ Subaward/Consortium
Organization: JOHNS HOPKINS UNIVERSITY

Start Date*: 07-01-2020 **End Date*:** 06-30-2021 **Budget Period: 1**

C. Equipment Description

List items and dollar amount for each item exceeding $5,000

Equipment Item	**Funds Requested ($)***
1 . One SonoBook9 veterinary portable ultrasound machine	22,655.00
2 . iSTAT Handheld Blood Analyzer	7,000.00
3 . Marmoset cages	80,000.00
Total funds requested for all equipment listed in the attached file	
Total Equipment	**109,655.00**

Additional Equipment: File Name:

D. Travel	**Funds Requested ($)***
1. Domestic Travel Costs (Incl. Canada, Mexico, and U.S. Possessions)	3,000.00
2. Foreign Travel Costs	
Total Travel Cost	**3,000.00**

E. Participant/Trainee Support Costs		**Funds Requested ($)***
1. Tuition/Fees/Health Insurance		
2. Stipends		
3. Travel		
4. Subsistence		
5. Other:		
Number of Participants/Trainees	**Total Participant Trainee Support Costs**	**0.00**

RESEARCH & RELATED Budget {C-E} (Funds Requested)

RESEARCH & RELATED BUDGET - SECTIONS F-K, Budget Period 1

ORGANIZATIONAL DUNS*: 0019107770000
Budget Type*: ● Project ❍ Subaward/Consortium
Organization: JOHNS HOPKINS UNIVERSITY

Start Date*: 07-01-2020 **End Date*:** 06-30-2021 **Budget Period: 1**

F. Other Direct Costs	Funds Requested ($)*
1. Materials and Supplies	46,000.00
2. Publication Costs	
3. Consultant Services	
4. ADP/Computer Services	
5. Subawards/Consortium/Contractual Costs	485,002.00
6. Equipment or Facility Rental/User Fees	
7. Alterations and Renovations	
8 . Animal Purchases	200,000.00
9 . Animal Care	87,600.00
Total Other Direct Costs	**818,602.00**

G. Direct Costs	Funds Requested ($)*
Total Direct Costs (A thru F)	**1,133,596.00**

H. Indirect Costs

Indirect Cost Type	Indirect Cost Rate (%)	Indirect Cost Base ($)	Funds Requested ($)*
1 . MTDC	63.75	563,939.00	359,511.00
		Total Indirect Costs	**359,511.00**

Cognizant Federal Agency (Agency Name, POC Name, and POC Phone Number): Department of Health and Human Services, Steven Zuraf, (301) 492-4855

I. Total Direct and Indirect Costs	Funds Requested ($)*
Total Direct and Indirect Institutional Costs (G + H)	**1,493,107.00**

J. Fee	Funds Requested ($)*

K. Total Costs and Fee	Funds Requested ($)*
	1,493,107.00

L. Budget Justification* File Name: BudgetJustification_U24_v4.pdf
(Only attach one file.)

RESEARCH & RELATED Budget {F-K} (Funds Requested)

Tracking Number: GRANT12945120
Funding Opportunity Number: RFA-MH-20-145 . Received Date: 2019-10-03T16:24:07.000-04:00

OMB Number: 4040-0001
Expiration Date: 10/31/2019

RESEARCH & RELATED BUDGET - SECTION A & B, Budget Period 2

ORGANIZATIONAL DUNS*: 0019107770000

Budget Type*: ● Project ❍ Subaward/Consortium

Enter name of Organization: JOHNS HOPKINS UNIVERSITY

Start Date*: 07-01-2021 **End Date*:** 06-30-2022 **Budget Period: 2**

A. Senior/Key Person

	Prefix	First Name*	Middle Name	Last Name*	Suffix	Project Role*	Base Salary ($)	Calendar Months	Academic Months	Summer Months	Requested Salary ($)*	Fringe Benefits ($)*	Funds Requested ($)*
1 .		Xiaoqin		Wang		PD/PI	base salary & percent effort				19,230.00	6,442.00	25,672.00
2 .		Jessica		Izzi		Co-Investigator					61,460.00	20,589.00	82,049.00

Total Funds Requested for all Senior Key Persons in the attached file

Additional Senior Key Persons: File Name:

Total Senior/Key Person **107,721.00**

B. Other Personnel

Number of Personnel*	Project Role*	Calendar Months	Academic Months	Summer Months	Requested Salary ($)*	Fringe Benefits*	Funds Requested ($)*
	Post Doctoral Associates						
	Graduate Students						
	Undergraduate Students						
	Secretarial/Clerical						
2	Veternarian	percent effort			14,075.00	4,715.00	18,790.00
1	Colony Manager				60,770.00	20,358.00	81,128.00
3	**Total Number Other Personnel**					**Total Other Personnel**	**99,918.00**
						Total Salary, Wages and Fringe Benefits (A+B)	**207,639.00**

RESEARCH & RELATED Budget {A-B} (Funds Requested)

Funding Opportunity Number: RFA-MH-20-145 . Received Date: 2019-10-03T16:24:07.000-04:00

RESEARCH & RELATED BUDGET - SECTION C, D, & E, Budget Period 2

ORGANIZATIONAL DUNS*: 0019107770000
Budget Type*: ● Project ❍ Subaward/Consortium
Organization: JOHNS HOPKINS UNIVERSITY

Start Date*: 07-01-2021 **End Date*:** 06-30-2022 **Budget Period: 2**

C. Equipment Description

List items and dollar amount for each item exceeding $5,000

Equipment Item	**Funds Requested ($)***
1 . Marmoset cages	100,000.00
Total funds requested for all equipment listed in the attached file	
Total Equipment	**100,000.00**

Additional Equipment: File Name:

D. Travel	**Funds Requested ($)***
1. Domestic Travel Costs (Incl. Canada, Mexico, and U.S. Possessions)	3,090.00
2. Foreign Travel Costs	
Total Travel Cost	**3,090.00**

E. Participant/Trainee Support Costs		**Funds Requested ($)***
1. Tuition/Fees/Health Insurance		
2. Stipends		
3. Travel		
4. Subsistence		
5. Other:		
Number of Participants/Trainees	**Total Participant Trainee Support Costs**	**0.00**

RESEARCH & RELATED Budget {C-E} (Funds Requested)

Tracking Number: GRANT12945120
Funding Opportunity Number: RFA-MH-20-145 . Received Date: 2019-10-03T16:24:07.000-04:00

RESEARCH & RELATED BUDGET - SECTIONS F-K, Budget Period 2

ORGANIZATIONAL DUNS*: 0019107770000
Budget Type*: ● Project ❍ Subaward/Consortium
Organization: JOHNS HOPKINS UNIVERSITY

Start Date*: 07-01-2021 **End Date*:** 06-30-2022 **Budget Period: 2**

F. Other Direct Costs	Funds Requested ($)*
1. Materials and Supplies	32,296.00
2. Publication Costs	
3. Consultant Services	
4. ADP/Computer Services	
5. Subawards/Consortium/Contractual Costs	572,848.00
6. Equipment or Facility Rental/User Fees	
7. Alterations and Renovations	
8 . Animal Purchases	90,000.00
9 . Animal Care	169,178.00
Total Other Direct Costs	**864,322.00**

G. Direct Costs	Funds Requested ($)*
Total Direct Costs (A thru F)	**1,175,051.00**

H. Indirect Costs

Indirect Cost Type	Indirect Cost Rate (%)	Indirect Cost Base ($)	Funds Requested ($)*
1 . MTDC	63.75	502,203.00	320,154.00
		Total Indirect Costs	**320,154.00**

Cognizant Federal Agency (Agency Name, POC Name, and POC Phone Number): Department of Health and Human Services, Steven Zuraf, (301) 492-4855

I. Total Direct and Indirect Costs	Funds Requested ($)*
Total Direct and Indirect Institutional Costs (G + H)	**1,495,205.00**

J. Fee	Funds Requested ($)*

K. Total Costs and Fee	Funds Requested ($)*
	1,495,205.00

L. Budget Justification* File Name: BudgetJustification_U24_v4.pdf
(Only attach one file.)

RESEARCH & RELATED Budget {F-K} (Funds Requested)

Tracking Number: GRANT12945120
Funding Opportunity Number: RFA-MH-20-145 . Received Date: 2019-10-03T16:24:07.000-04:00

OMB Number: 4040-0001
Expiration Date: 10/31/2019

RESEARCH & RELATED BUDGET - SECTION A & B, Budget Period 3

ORGANIZATIONAL DUNS*: 0019107770000

Budget Type*: ● Project ○ Subaward/Consortium

Enter name of Organization: JOHNS HOPKINS UNIVERSITY

Start Date*: 07-01-2022 **End Date*:** 06-30-2023 **Budget Period:** 3

A. Senior/Key Person

Prefix	First Name*	Middle Name	Last Name*	Suffix	Project Role*	Base Salary ($)	Calendar Months	Academic Months	Summer Months	Requested Salary ($)*	Fringe Benefits ($)*	Funds Requested ($)*
1.	Xiaoqin		Wang		PD/PI	base salary & percent effort				19,230.00	6,442.00	25,672.00
2.	Jessica		Izzi		Co-Investigator					63,304.00	21,207.00	84,511.00

Total Funds Requested for all Senior Key Persons in the attached file

Additional Senior Key Persons: File Name:

Total Senior/Key Person **110,183.00**

B. Other Personnel

Number of Personnel*	Project Role*	Calendar Months	Academic Months	Summer Months	Requested Salary ($)*	Fringe Benefits*	Funds Requested ($)*
	Post Doctoral Associates						
	Graduate Students						
	Undergraduate Students						
	Secretarial/Clerical						
2	Veternarian	percent effort			14,498.00	4,856.00	19,354.00
1	Colony Manager				62,593.00	20,969.00	83,562.00
3	**Total Number Other Personnel**					**Total Other Personnel**	**102,916.00**
						Total Salary, Wages and Fringe Benefits (A+B)	**213,099.00**

RESEARCH & RELATED Budget {A-B} (Funds Requested)

Funding Opportunity Number: RFA-MH-20-145 . Received Date: 2019-10-03T16:24:07.000-04:00

RESEARCH & RELATED BUDGET - SECTION C, D, & E, Budget Period 3

ORGANIZATIONAL DUNS*: 0019107770000
Budget Type*: ● Project ❍ Subaward/Consortium
Organization: JOHNS HOPKINS UNIVERSITY

Start Date*: 07-01-2022 **End Date*:** 06-30-2023 **Budget Period: 3**

C. Equipment Description		
List items and dollar amount for each item exceeding $5,000		
Equipment Item		**Funds Requested ($)***
Total funds requested for all equipment listed in the attached file		
	Total Equipment	**0.00**

Additional Equipment: File Name:

D. Travel	**Funds Requested ($)***
1. Domestic Travel Costs (Incl. Canada, Mexico, and U.S. Possessions)	3,183.00
2. Foreign Travel Costs	
Total Travel Cost	**3,183.00**

E. Participant/Trainee Support Costs		**Funds Requested ($)***
1. Tuition/Fees/Health Insurance		
2. Stipends		
3. Travel		
4. Subsistence		
5. Other:		
Number of Participants/Trainees	**Total Participant Trainee Support Costs**	**0.00**

RESEARCH & RELATED Budget {C-E} (Funds Requested)

RESEARCH & RELATED BUDGET - SECTIONS F-K, Budget Period 3

ORGANIZATIONAL DUNS*: 0019107770000
Budget Type*: ● Project ❍ Subaward/Consortium
Organization: JOHNS HOPKINS UNIVERSITY

Start Date*: 07-01-2022 **End Date*:** 06-30-2023 **Budget Period: 3**

F. Other Direct Costs	Funds Requested ($)*
1. Materials and Supplies	32,704.00
2. Publication Costs	
3. Consultant Services	
4. ADP/Computer Services	
5. Subawards/Consortium/Contractual Costs	640,810.00
6. Equipment or Facility Rental/User Fees	
7. Alterations and Renovations	
8 . Animal Purchases	50,000.00
9 . Animal Care	223,044.00
Total Other Direct Costs	**946,558.00**

G. Direct Costs	Funds Requested ($)*
Total Direct Costs (A thru F)	**1,162,840.00**

H. Indirect Costs

Indirect Cost Type	Indirect Cost Rate (%)	Indirect Cost Base ($)	Funds Requested ($)*
1 . MTDC	63.75	522,030.00	332,794.00
		Total Indirect Costs	**332,794.00**

Cognizant Federal Agency (Agency Name, POC Name, and POC Phone Number): Department of Health and Human Services, Steven Zuraf, (301) 492-4855

I. Total Direct and Indirect Costs	Funds Requested ($)*
Total Direct and Indirect Institutional Costs (G + H)	**1,495,634.00**

J. Fee	Funds Requested ($)*

K. Total Costs and Fee	Funds Requested ($)*
	1,495,634.00

L. Budget Justification* File Name: BudgetJustification_U24_v4.pdf
(Only attach one file.)

RESEARCH & RELATED Budget {F-K} (Funds Requested)

Tracking Number: GRANT12945120
Funding Opportunity Number: RFA-MH-20-145 . Received Date: 2019-10-03T16:24:07.000-04:00

OMB Number: 4040-0001
Expiration Date: 10/31/2019

RESEARCH & RELATED BUDGET - SECTION A & B, Budget Period 4

ORGANIZATIONAL DUNS*: 0019107770000

Budget Type*: ● Project ○ Subaward/Consortium

Enter name of Organization: JOHNS HOPKINS UNIVERSITY

Start Date*: 07-01-2023 **End Date*:** 06-30-2024 **Budget Period:** 4

A. Senior/Key Person

Prefix	First Name*	Middle Name	Last Name*	Suffix	Project Role*	Base Salary ($)	Calendar Months	Academic Months	Summer Months	Requested Salary ($)*	Fringe Benefits ($)*	Funds Requested ($)*
1.	Xiaoqin		Wang		PD/PI	base salary & percent effort				19,230.00	6,442.00	25,672.00
2.	Jessica		Izzi		Co-Investigator					65,203.00	21,843.00	87,046.00

Total Funds Requested for all Senior Key Persons in the attached file

Additional Senior Key Persons: File Name:

Total Senior/Key Person **112,718.00**

B. Other Personnel

Number of Personnel*	Project Role*	Calendar Months	Academic Months	Summer Months	Requested Salary ($)*	Fringe Benefits*	Funds Requested ($)*
	Post Doctoral Associates						
	Graduate Students						
	Undergraduate Students						
	Secretarial/Clerical						
2	Veternarian	percent effort			14,932.00	5,002.00	19,934.00
1	Colony Manager				64,471.00	21,598.00	86,069.00
3	**Total Number Other Personnel**					**Total Other Personnel**	**106,003.00**
						Total Salary, Wages and Fringe Benefits (A+B)	**218,721.00**

RESEARCH & RELATED Budget {A-B} (Funds Requested)

Funding Opportunity Number: RFA-MH-20-145 . Received Date: 2019-10-03T16:24:07.000-04:00

RESEARCH & RELATED BUDGET - SECTION C, D, & E, Budget Period 4

ORGANIZATIONAL DUNS*: 0019107770000
Budget Type*: ● Project ❍ Subaward/Consortium
Organization: JOHNS HOPKINS UNIVERSITY

Start Date*: 07-01-2023 **End Date*:** 06-30-2024 **Budget Period: 4**

C. Equipment Description		
List items and dollar amount for each item exceeding $5,000		
Equipment Item		**Funds Requested ($)***
Total funds requested for all equipment listed in the attached file		
	Total Equipment	**0.00**

Additional Equipment: File Name:

D. Travel		Funds Requested ($)*
1. Domestic Travel Costs (Incl. Canada, Mexico, and U.S. Possessions)		3,278.00
2. Foreign Travel Costs		
	Total Travel Cost	**3,278.00**

E. Participant/Trainee Support Costs		Funds Requested ($)*
1. Tuition/Fees/Health Insurance		
2. Stipends		
3. Travel		
4. Subsistence		
5. Other:		
Number of Participants/Trainees	**Total Participant Trainee Support Costs**	**0.00**

RESEARCH & RELATED Budget {C-E} (Funds Requested)

RESEARCH & RELATED BUDGET - SECTIONS F-K, Budget Period 4

ORGANIZATIONAL DUNS*: 0019107770000
Budget Type*: ● Project ❍ Subaward/Consortium
Organization: JOHNS HOPKINS UNIVERSITY

Start Date*: 07-01-2023 **End Date*:** 06-30-2024 **Budget Period: 4**

F. Other Direct Costs	Funds Requested ($)*
1. Materials and Supplies	33,124.00
2. Publication Costs	1,500.00
3. Consultant Services	
4. ADP/Computer Services	
5. Subawards/Consortium/Contractual Costs	572,980.00
6. Equipment or Facility Rental/User Fees	
7. Alterations and Renovations	
8 . Animal Purchases	30,000.00
9 . Animal Care	275,203.00
Total Other Direct Costs	**912,807.00**

G. Direct Costs	Funds Requested ($)*
Total Direct Costs (A thru F)	**1,134,806.00**

H. Indirect Costs

Indirect Cost Type	Indirect Cost Rate (%)	Indirect Cost Base ($)	Funds Requested ($)*
1 . MTDC	63.75	561,826.00	358,164.00
		Total Indirect Costs	**358,164.00**

Cognizant Federal Agency (Agency Name, POC Name, and POC Phone Number): Department of Health and Human Services, Steven Zuraf, (301) 492-4855

I. Total Direct and Indirect Costs	Funds Requested ($)*
Total Direct and Indirect Institutional Costs (G + H)	**1,492,970.00**

J. Fee	Funds Requested ($)*

K. Total Costs and Fee	Funds Requested ($)*
	1,492,970.00

L. Budget Justification* File Name: BudgetJustification_U24_v4.pdf
(Only attach one file.)

RESEARCH & RELATED Budget {F-K} (Funds Requested)

Tracking Number: GRANT12945120
Funding Opportunity Number: RFA-MH-20-145 . Received Date: 2019-10-03T16:24:07.000-04:00

OMB Number: 4040-0001
Expiration Date: 10/31/2019

RESEARCH & RELATED BUDGET - SECTION A & B, Budget Period 5

ORGANIZATIONAL DUNS*: 0019107770000

Budget Type*: ● Project ○ Subaward/Consortium

Enter name of Organization: JOHNS HOPKINS UNIVERSITY

Start Date*: 07-01-2024 **End Date*:** 06-30-2025 **Budget Period:** 5

A. Senior/Key Person

Prefix	First Name*	Middle Name	Last Name*	Suffix	Project Role*	Base Salary ($)	Calendar Months	Academic Months	Summer Months	Requested Salary ($)*	Fringe Benefits ($)*	Funds Requested ($)*
1.	Xiaoqin		Wang		PD/PI	base salary & percent effort				19,230.00	6,442.00	25,672.00
2.	Jessica		Izzi		Co-Investigator					67,159.00	22,498.00	89,657.00

Total Funds Requested for all Senior Key Persons in the attached file

Additional Senior Key Persons: File Name:

Total Senior/Key Person **115,329.00**

B. Other Personnel

Number of Personnel*	Project Role*	Calendar Months	Academic Months	Summer Months	Requested Salary ($)*	Fringe Benefits*	Funds Requested ($)*
	Post Doctoral Associates						
	Graduate Students						
	Undergraduate Students						
	Secretarial/Clerical						
2	Veternarian	percent effort			15,380.00	5,152.00	20,532.00
1	Colony Manager				66,405.00	22,246.00	88,651.00
3	**Total Number Other Personnel**					**Total Other Personnel**	**109,183.00**
						Total Salary, Wages and Fringe Benefits (A+B)	**224,512.00**

RESEARCH & RELATED Budget {A-B} (Funds Requested)

Funding Opportunity Number: RFA-MH-20-145 . Received Date: 2019-10-03T16:24:07.000-04:00

RESEARCH & RELATED BUDGET - SECTION C, D, & E, Budget Period 5

ORGANIZATIONAL DUNS*: 0019107770000
Budget Type*: ● Project ❍ Subaward/Consortium
Organization: JOHNS HOPKINS UNIVERSITY

Start Date*: 07-01-2024 **End Date*:** 06-30-2025 **Budget Period: 5**

C. Equipment Description		
List items and dollar amount for each item exceeding $5,000		
Equipment Item		**Funds Requested ($)***
Total funds requested for all equipment listed in the attached file		
	Total Equipment	**0.00**

Additional Equipment: File Name:

D. Travel	**Funds Requested ($)***
1. Domestic Travel Costs (Incl. Canada, Mexico, and U.S. Possessions)	3,377.00
2. Foreign Travel Costs	
Total Travel Cost	**3,377.00**

E. Participant/Trainee Support Costs		**Funds Requested ($)***
1. Tuition/Fees/Health Insurance		
2. Stipends		
3. Travel		
4. Subsistence		
5. Other:		
Number of Participants/Trainees	**Total Participant Trainee Support Costs**	**0.00**

RESEARCH & RELATED Budget {C-E} (Funds Requested)

RESEARCH & RELATED BUDGET - SECTIONS F-K, Budget Period 5

ORGANIZATIONAL DUNS*: 0019107770000
Budget Type*: ● Project ❍ Subaward/Consortium
Organization: JOHNS HOPKINS UNIVERSITY

Start Date*: 07-01-2024 **End Date*:** 06-30-2025 **Budget Period: 5**

F. Other Direct Costs	Funds Requested ($)*
1. Materials and Supplies	33,557.00
2. Publication Costs	2,000.00
3. Consultant Services	
4. ADP/Computer Services	
5. Subawards/Consortium/Contractual Costs	597,480.00
6. Equipment or Facility Rental/User Fees	
7. Alterations and Renovations	
8 . Animal Care	283,459.00
Total Other Direct Costs	**916,496.00**

G. Direct Costs	Funds Requested ($)*
Total Direct Costs (A thru F)	**1,144,385.00**

H. Indirect Costs

Indirect Cost Type	Indirect Cost Rate (%)	Indirect Cost Base ($)	Funds Requested ($)*
1 . MTDC	63.75	546,905.00	348,652.00
		Total Indirect Costs	**348,652.00**

Cognizant Federal Agency (Agency Name, POC Name, and POC Phone Number)	Department of Health and Human Services, Steven Zuraf, (301) 492-4855

I. Total Direct and Indirect Costs	Funds Requested ($)*
Total Direct and Indirect Institutional Costs (G + H)	**1,493,037.00**

J. Fee	Funds Requested ($)*

K. Total Costs and Fee	Funds Requested ($)*
	1,493,037.00

L. Budget Justification*	File Name: BudgetJustification_U24_v4.pdf (Only attach one file.)

RESEARCH & RELATED Budget {F-K} (Funds Requested)

Tracking Number: GRANT12945120
Funding Opportunity Number: RFA-MH-20-145 . Received Date: 2019-10-03T16:24:07.000-04:00

Budget Justification (JHU)

Personnel:

Xiaoqin Wang, PhD. (P.I., [redacted] Years 1-5) will oversee the entire operation in the center and coordinate activities among all involved units. P.I. will supervise all personnel.

Jessica Izzi, DVM, MLAS, DACLAM (co-I, Veterinarian, [redacted] Years 1-5) will be responsible for day-to-day clinical and surgical care of all animals, coordination of all breeding and genotyping efforts described in the proposal, arranging transport of animals and materials across institutions, and supervision of colony manager and technician.

Eric Hutchinson, DVM, DACLAM (Veterinarian, [redacted] Years 1-5) will be responsible for providing back-up veterinary support for all animals and assisting with management of breeding and genotyping efforts.

Sarah Beck, DVM, PhD, DACVP (Veterinary Pathologist, [redacted], Years 1-5) will responsible for conducting necropsies on all deceased animals and advisement on colony health or management concerns based on necropsy results.

Colony manager ([redacted] Years 1-5) will be hired to assist PI and veterinary staff with daily management of breeding colony, maintaining breeding software program, coordinating collection of samples for genotyping efforts, maintaining thorough breeding histories for all animals in colony, coordination and conduction of pairing and weaning animals, daily observations and provision of prescribed treatments to all animals and reporting data and trends to PI and veterinary staff.

The fringe and benefits rates are 33.5% for faculty and staffs (PI, technician and research scientist) beginning June 6, 2019 and 19% for postdoctoral fellows. Postdoctoral stipends are based on current NIH NRSA stipend scales and years of experience.

Animal expenses:

Animal purchases: We plan to purchase 40 marmosets (20 breeding pairs) in Year 1, 18 marmosets (9 breeding pairs) in Year 2, 10 marmosets in Year 3 (5 breeding pairs) and 6 marmosets (3 breeding pairs) in Year 4 at $5,000/ea. These animals will be used as breeders in the colony at Johns Hopkins University for this award.

Animal care per diem: We have budgeted housing 40, 75, 96, 115 and 115 marmosets in Years 1-5, respectively, at JHU per diem rate of $6.00 per animal per day.

Materials and supplies

Clinical, surgical, and storage supplies (Year-1: $14,100):

- Liquid nitrogen tank (for sperm storage) = $300
- Refrigerator for feed storage (1 for regular diet, 1 for enrichment) ($1,000 each x 2 =$2,000)
- Small refrigerator for storage of refrigerated drugs ($150)
- Medical supplies cabinets (1 for PPE, 1 for drugs, 1 for supplies) ($1,000 each x 3 = $3,000)
- 3M Bair Hugger warming units (for minor procedures, critical and infant care) ($700 x 2 = $1,400)
- Blood sample analysis tools: centrifuge, refractometer ($1,000)
- Fluid warming cabinet = $3,000
- Animal transport cages ($25 each x 10 =$250)
- Portable SPO2 monitor = $1,000
- Computers for colony management ($2,000)

Non-human primate operating suite rental fees (Years 1-5: $1,200/year)
for C-sections or other clinical procedures ($50/hr x2hr/surgery x 12 surgeries/year = $1,200/year)

Medical supplies: (Years 1-5: $12,000/year):
drugs, syringes, needles, gloves, fluids, thermometers, gauze, etc. ($1,000/month x 12 months = $12,000/year)

Clinical testing to ensure SPF status of breeding colony, Years 1-5 ($18,700 in Year-1, total 5 year budget = $93,500):

1) In-house CBC and Chemistry panels ($28,500).
($75 each): test prior to entry into breeding colony then annually
Year 1 total cost = $75 x 40 (20 pairs) = $3,000
Year 2 total cost = $75 x 60 (30 pairs) = $4,500
Year 3 total cost = $75 x 80 (40 pairs) = $6,000
Year 4 total cost = $75 x 100 (50 pairs) = $7,500
Year 5 total cost = $75 x 100 (50 pairs) = $7,500

2) *Giardia* ELISA ($29,000).
($50 each): 3 negative tests prior to entry into breeding colony then 1x annually (single test)
Year 1 total cost = $50 x 3 (includes initial 3 tests) x 40 (20 pairs) = $6,000
Year 2 total cost = ($50 x 20 x 3) (includes initial 3 tests for 10 new breeding pairs) + ($50 x 40 x 1) (includes annual tests for 20 old pairs) = $5,000
Year 3 total cost = ($50 x 20 x 3) (includes initial 3 tests for 10 new breeding pairs plus second annual test) + ($50 x 60 x 1) (includes annual tests for 30 old pairs) = $6,000
Year 4 total cost = ($50 x 20 x 3) (includes initial 3 tests for 10 new breeding pairs plus second annual test) + ($50 x 80 x 1) (includes annual tests for 40 old pairs) = $7,000
Year 5 total cost = $50 x 100 x 1 (annual tests for 50 breeding pairs) = $5,000

3) *Klebsiella pneumoniae* PCR ($36,000).
($75 each): 1 oral + 1 fecal PCR prior to entry into breeding colony then fecal PCR 1x annually
Year 1 total cost = $75 x 2 (oral and fecal for entry) x 40 (20 pairs) = $6,000
Year 2 total cost = ($75 x 20 x 2) + ($75 x 40 x 1) = $6,000
Year 3 total cost = ($75 x 20 x 2) + ($75 x 60 x 1) = $7,500
Year 4 total cost = ($75 x 20 x 2) + ($75 x 80 x 1) = $9,000
Year 5 total cost = $75 x 100 x 1 (annual tests for 50 breeding pairs) = $7,500

Major Equipment:

1) Year 1: One SonoBook9 veterinary portable ultrasound machine by Chison ($22,655. Required for detecting pregnancy and evaluating fetal and maternal health)
2) Year 1: iSTAT Handheld Blood Analyzer by Abbott ($7,000). Required for emergency/point-of-care bloodwork.
3) Years 1-2: Marmoset caging designed by Tecniplast. Current collaboration underway to design marmoset caging that can house up to 4 breeding pairs in one caging system. (8 in Year 1 and 10 in Year 2 at $10,000 each)

Publication costs: The request amount will pay for 1 publication in journals in final project years ($1,500 Year 4, $2,000 Year 5) to report findings from this project regarding animal husbandry questions.

Travel: The funds requested will allow the P.I., co-PI or veterinarians working on the project to attend one annual scientific meetings. Two travels per year are requested for Years 1-5 ($1,500/per trip, per person).

Other Expenses: None.

Note: Expenses after Year-1 are increased by 3% per annum to allow for inflation raises, except for postdoctoral fellow's stipend (based on NIH NRSA stipend guideline).

RESEARCH & RELATED BUDGET - Cumulative Budget

	Totals ($)	
Section A, Senior/Key Person		551,282.00
Section B, Other Personnel		515,028.00
Total Number Other Personnel	15	
Total Salary, Wages and Fringe Benefits (A+B)		1,066,310.00
Section C, Equipment		209,655.00
Section D, Travel		15,928.00
1. Domestic	15,928.00	
2. Foreign	0.00	
Section E, Participant/Trainee Support Costs		0.00
1. Tuition/Fees/Health Insurance	0.00	
2. Stipends	0.00	
3. Travel	0.00	
4. Subsistence	0.00	
5. Other	0.00	
6. Number of Participants/Trainees	0	
Section F, Other Direct Costs		4,458,785.00
1. Materials and Supplies	177,681.00	
2. Publication Costs	3,500.00	
3. Consultant Services	0.00	
4. ADP/Computer Services	0.00	
5. Subawards/Consortium/Contractual Costs	2,869,120.00	
6. Equipment or Facility Rental/User Fees	0.00	
7. Alterations and Renovations	0.00	
8. Other 1	653,459.00	
9. Other 2	755,025.00	
10. Other 3	0.00	
Section G, Direct Costs (A thru F)		5,750,678.00
Section H, Indirect Costs		1,719,275.00
Section I, Total Direct and Indirect Costs (G + H)		7,469,953.00
Section J, Fee		0.00
Section K, Total Costs and Fee (I + J)		7,469,953.00

Funding Opportunity Number: RFA-MH-20-145 . Received Date: 2019-10-03T16:24:07.000-04:00

OMB Number: 4040-0001
Expiration Date: 10/31/2019

RESEARCH & RELATED BUDGET - SECTION A & B, Budget Period 1

ORGANIZATIONAL DUNS*: 8043557900000

Budget Type*: ○ Project ● Subaward/Consortium

Enter name of Organization: The Regents of the University of California, U.C. San Diego

Start Date*: 07-01-2020 **End Date*:** 06-30-2021 **Budget Period: 1**

A. Senior/Key Person

Prefix	First Name*	Middle Name	Last Name*	Suffix	Project Role*	Base Salary ($)	Calendar Months	Academic Months	Summer Months	Requested Salary ($)*	Fringe Benefits ($)*	Funds Requested ($)*
1 . Dr.	Cory		Miller		PI		[redacted] percent effort			13,515.00	5,054.00	18,569.00

Total Funds Requested for all Senior Key Persons in the attached file

Additional Senior Key Persons: File Name: **Total Senior/Key Person** **18,569.00**

B. Other Personnel

Number of Personnel*	Project Role*	Calendar Months	Academic Months	Summer Months	Requested Salary ($)*	Fringe Benefits*	Funds Requested ($)*
	Post Doctoral Associates						
	Graduate Students						
	Undergraduate Students						
	Secretarial/Clerical						
1	Veterianarian	[redacted] percent effort			15,616.00	7,012.00	22,628.00
1	Animal Technician Sr				47,163.00	21,176.00	68,339.00
2	**Total Number Other Personnel**					**Total Other Personnel**	**90,967.00**
						Total Salary, Wages and Fringe Benefits (A+B)	**109,536.00**

RESEARCH & RELATED Budget {A-B} (Funds Requested)

Funding Opportunity Number: RFA-MH-20-145 . Received Date: 2019-10-03T16:24:07.000-04:00

RESEARCH & RELATED BUDGET - SECTION C, D, & E, Budget Period 1

ORGANIZATIONAL DUNS*: 8043557900000

Budget Type*: ❍ Project ● Subaward/Consortium

Organization: The Regents of the University of California, U.C. San Diego

Start Date*: 07-01-2020 **End Date*:** 06-30-2021 **Budget Period: 1**

C. Equipment Description

List items and dollar amount for each item exceeding $5,000

Equipment Item	**Funds Requested ($)***
1 . Cages	80,250.00
Total funds requested for all equipment listed in the attached file	
Total Equipment	**80,250.00**

Additional Equipment: File Name:

D. Travel	**Funds Requested ($)***
1. Domestic Travel Costs (Incl. Canada, Mexico, and U.S. Possessions)	
2. Foreign Travel Costs	
Total Travel Cost	**0.00**

E. Participant/Trainee Support Costs		**Funds Requested ($)***
1. Tuition/Fees/Health Insurance		
2. Stipends		
3. Travel		
4. Subsistence		
5. Other:		
Number of Participants/Trainees	**Total Participant Trainee Support Costs**	**0.00**

RESEARCH & RELATED Budget {C-E} (Funds Requested)

RESEARCH & RELATED BUDGET - SECTIONS F-K, Budget Period 1

ORGANIZATIONAL DUNS*: 8043557900000

Budget Type*: ❍ Project ● Subaward/Consortium

Organization: The Regents of the University of California, U.C. San Diego

Start Date*: 07-01-2020 **End Date*:** 06-30-2021 **Budget Period: 1**

F. Other Direct Costs	Funds Requested ($)*
1. Materials and Supplies	
2. Publication Costs	
3. Consultant Services	
4. ADP/Computer Services	
5. Subawards/Consortium/Contractual Costs	
6. Equipment or Facility Rental/User Fees	
7. Alterations and Renovations	
8 . Breeding Colony Housing Costs & Annual Health Exams and Tests	76,089.00
9 . Animal Purchases & Transportation	70,000.00
10 . Telecommunications	1,360.00
Total Other Direct Costs	**147,449.00**

G. Direct Costs	Funds Requested ($)*
Total Direct Costs (A thru F)	**337,235.00**

H. Indirect Costs

Indirect Cost Type	Indirect Cost Rate (%)	Indirect Cost Base ($)	Funds Requested ($)*
1 . MTDC on Campus Rate	57.5	256,985.00	147,767.00
		Total Indirect Costs	**147,767.00**

Cognizant Federal Agency (Agency Name, POC Name, and POC Phone Number) DHHS, Region IX, 415-437-7820

I. Total Direct and Indirect Costs	Funds Requested ($)*
Total Direct and Indirect Institutional Costs (G + H)	**485,002.00**

J. Fee	Funds Requested ($)*

K. Total Costs and Fee	Funds Requested ($)*
	485,002.00

L. Budget Justification* File Name: BudgetJustification.pdf
(Only attach one file.)

RESEARCH & RELATED Budget {F-K} (Funds Requested)

OMB Number: 4040-0001
Expiration Date: 10/31/2019

RESEARCH & RELATED BUDGET - SECTION A & B, Budget Period 2

ORGANIZATIONAL DUNS*: 8043557900000

Budget Type*: ○ Project ● Subaward/Consortium

Enter name of Organization: The Regents of the University of California, U.C. San Diego

Start Date*: 07-01-2021 **End Date*:** 06-30-2022 **Budget Period: 2**

A. Senior/Key Person

Prefix	First Name*	Middle Name	Last Name*	Suffix	Project Role*	Base Salary ($)	Calendar Months	Academic Months	Summer Months	Requested Salary ($)*	Fringe Benefits ($)*	Funds Requested ($)*
1 . Dr.	Cory		Miller		PI		[redacted] percent effort			14,055.00	5,313.00	19,368.00

Total Funds Requested for all Senior Key Persons in the attached file

Additional Senior Key Persons: File Name: **Total Senior/Key Person** **19,368.00**

B. Other Personnel

Number of Personnel*	Project Role*	Calendar Months	Academic Months	Summer Months	Requested Salary ($)*	Fringe Benefits*	Funds Requested ($)*
	Post Doctoral Associates						
	Graduate Students						
	Undergraduate Students						
	Secretarial/Clerical						
1	Veterianarian	[redacted] percent effort			16,085.00	7,303.00	23,388.00
1	Animal Technician Sr				48,578.00	22,054.00	70,632.00
2	**Total Number Other Personnel**					**Total Other Personnel**	**94,020.00**
						Total Salary, Wages and Fringe Benefits (A+B)	**113,388.00**

RESEARCH & RELATED Budget {A-B} (Funds Requested)

Funding Opportunity Number: RFA-MH-20-145 . Received Date: 2019-10-03T16:24:07.000-04:00

RESEARCH & RELATED BUDGET - SECTION C, D, & E, Budget Period 2

ORGANIZATIONAL DUNS*: 8043557900000

Budget Type*: ❍ Project ● Subaward/Consortium

Organization: The Regents of the University of California, U.C. San Diego

Start Date*: 07-01-2021 **End Date*:** 06-30-2022 **Budget Period: 2**

C. Equipment Description

List items and dollar amount for each item exceeding $5,000

Equipment Item	**Funds Requested ($)***
1 . Cages	66,126.00
Total funds requested for all equipment listed in the attached file	
Total Equipment	**66,126.00**

Additional Equipment: File Name:

D. Travel	**Funds Requested ($)***
1. Domestic Travel Costs (Incl. Canada, Mexico, and U.S. Possessions)	
2. Foreign Travel Costs	
Total Travel Cost	**0.00**

E. Participant/Trainee Support Costs		**Funds Requested ($)***
1. Tuition/Fees/Health Insurance		
2. Stipends		
3. Travel		
4. Subsistence		
5. Other:		
Number of Participants/Trainees	**Total Participant Trainee Support Costs**	**0.00**

RESEARCH & RELATED Budget {C-E} (Funds Requested)

RESEARCH & RELATED BUDGET - SECTIONS F-K, Budget Period 2

ORGANIZATIONAL DUNS*: 8043557900000
Budget Type*: ❍ Project ● Subaward/Consortium
Organization: The Regents of the University of California, U.C. San Diego

Start Date*: 07-01-2021 **End Date*:** 06-30-2022 **Budget Period: 2**

F. Other Direct Costs	Funds Requested ($)*
1. Materials and Supplies	
2. Publication Costs	
3. Consultant Services	
4. ADP/Computer Services	
5. Subawards/Consortium/Contractual Costs	
6. Equipment or Facility Rental/User Fees	
7. Alterations and Renovations	
8 . Breeding Colony Housing Costs & Annual Health Exams and Tests	145,921.00
9 . Animal Purchases & Transportation	60,000.00
10 . Telecommunications	1,401.00
Total Other Direct Costs	**207,322.00**

G. Direct Costs	Funds Requested ($)*
Total Direct Costs (A thru F)	**386,836.00**

H. Indirect Costs

Indirect Cost Type	Indirect Cost Rate (%)	Indirect Cost Base ($)	Funds Requested ($)*
1 . MTDC on Campus Rate	58.0	320,710.00	186,012.00
		Total Indirect Costs	**186,012.00**

Cognizant Federal Agency DHHS, Region IX, 415-437-7820
(Agency Name, POC Name, and POC Phone Number)

I. Total Direct and Indirect Costs	Funds Requested ($)*
Total Direct and Indirect Institutional Costs (G + H)	**572,848.00**

J. Fee	Funds Requested ($)*

K. Total Costs and Fee	Funds Requested ($)*
	572,848.00

L. Budget Justification* File Name: BudgetJustification.pdf
(Only attach one file.)

RESEARCH & RELATED Budget {F-K} (Funds Requested)

Tracking Number: GRANT12945120
Funding Opportunity Number: RFA-MH-20-145 . Received Date: 2019-10-03T16:24:07.000-04:00

OMB Number: 4040-0001
Expiration Date: 10/31/2019

RESEARCH & RELATED BUDGET - SECTION A & B, Budget Period 3

ORGANIZATIONAL DUNS*: 8043557900000

Budget Type*: ○ Project ● Subaward/Consortium

Enter name of Organization: The Regents of the University of California, U.C. San Diego

Start Date*: 07-01-2022 **End Date*:** 06-30-2023 **Budget Period:** 3

A. Senior/Key Person

Prefix	First Name*	Middle Name	Last Name*	Suffix	Project Role*	Base Salary ($)	Calendar Months	Academic Months	Summer Months	Requested Salary ($)*	Fringe Benefits ($)*	Funds Requested ($)*
1 . Dr.	Cory		Miller		PI		[redacted] percent effort			14,617.00	5,555.00	20,172.00

Total Funds Requested for all Senior Key Persons in the attached file

Additional Senior Key Persons: File Name: **Total Senior/Key Person** **20,172.00**

B. Other Personnel

Number of Personnel*	Project Role*	Calendar Months	Academic Months	Summer Months	Requested Salary ($)*	Fringe Benefits*	Funds Requested ($)*
	Post Doctoral Associates						
	Graduate Students						
	Undergraduate Students						
	Secretarial/Clerical						
1	Veterianarian	[redacted] percent effort			16,567.00	7,571.00	24,138.00
1	Animal Technician Sr				50,036.00	22,866.00	72,902.00
2	**Total Number Other Personnel**					**Total Other Personnel**	**97,040.00**
						Total Salary, Wages and Fringe Benefits (A+B)	**117,212.00**

RESEARCH & RELATED Budget {A-B} (Funds Requested)

Funding Opportunity Number: RFA-MH-20-145 . Received Date: 2019-10-03T16:24:07.000-04:00

RESEARCH & RELATED BUDGET - SECTION C, D, & E, Budget Period 3

ORGANIZATIONAL DUNS*: 8043557900000

Budget Type*: ❍ Project ● Subaward/Consortium

Organization: The Regents of the University of California, U.C. San Diego

Start Date*: 07-01-2022 **End Date*:** 06-30-2023 **Budget Period: 3**

C. Equipment Description

List items and dollar amount for each item exceeding $5,000

Equipment Item	**Funds Requested ($)***
1 . Cages	45,407.00
Total funds requested for all equipment listed in the attached file	
Total Equipment	**45,407.00**

Additional Equipment: File Name:

D. Travel	**Funds Requested ($)***
1. Domestic Travel Costs (Incl. Canada, Mexico, and U.S. Possessions)	
2. Foreign Travel Costs	
Total Travel Cost	**0.00**

E. Participant/Trainee Support Costs		**Funds Requested ($)***
1. Tuition/Fees/Health Insurance		
2. Stipends		
3. Travel		
4. Subsistence		
5. Other:		
Number of Participants/Trainees	**Total Participant Trainee Support Costs**	**0.00**

RESEARCH & RELATED Budget {C-E} (Funds Requested)

Funding Opportunity Number: RFA-MH-20-145 . Received Date: 2019-10-03T16:24:07.000-04:00

RESEARCH & RELATED BUDGET - SECTIONS F-K, Budget Period 3

ORGANIZATIONAL DUNS*: 8043557900000

Budget Type*: ❍ Project ● Subaward/Consortium

Organization: The Regents of the University of California, U.C. San Diego

Start Date*: 07-01-2022 **End Date*:** 06-30-2023 **Budget Period: 3**

F. Other Direct Costs	Funds Requested ($)*
1. Materials and Supplies	
2. Publication Costs	
3. Consultant Services	
4. ADP/Computer Services	
5. Subawards/Consortium/Contractual Costs	
6. Equipment or Facility Rental/User Fees	
7. Alterations and Renovations	
8 . Breeding Colony Housing Costs & Annual Health Exams and Tests	208,182.00
9 . Animal Purchases & Transportation	50,000.00
10 . Telecommunications	1,443.00
Total Other Direct Costs	**259,625.00**

G. Direct Costs	Funds Requested ($)*
Total Direct Costs (A thru F)	**422,244.00**

H. Indirect Costs

Indirect Cost Type	Indirect Cost Rate (%)	Indirect Cost Base ($)	Funds Requested ($)*
1 . MTDC on Campus Rate	58.0	376,837.00	218,566.00
		Total Indirect Costs	**218,566.00**

Cognizant Federal Agency DHHS, Region IX, 415-437-7820
(Agency Name, POC Name, and POC Phone Number)

I. Total Direct and Indirect Costs	Funds Requested ($)*
Total Direct and Indirect Institutional Costs (G + H)	**640,810.00**

J. Fee	Funds Requested ($)*

K. Total Costs and Fee	Funds Requested ($)*
	640,810.00

L. Budget Justification* File Name: BudgetJustification.pdf
(Only attach one file.)

RESEARCH & RELATED Budget {F-K} (Funds Requested)

Tracking Number: GRANT12945120
Funding Opportunity Number: RFA-MH-20-145 . Received Date: 2019-10-03T16:24:07.000-04:00

OMB Number: 4040-0001
Expiration Date: 10/31/2019

RESEARCH & RELATED BUDGET - SECTION A & B, Budget Period 4

ORGANIZATIONAL DUNS*: 8043557900000

Budget Type*: ○ Project ● Subaward/Consortium

Enter name of Organization: The Regents of the University of California, U.C. San Diego

Start Date*: 07-01-2023 **End Date*:** 06-30-2024 **Budget Period:** 4

A. Senior/Key Person

Prefix	First Name*	Middle Name	Last Name*	Suffix	Project Role*	Base Salary ($)	Calendar Months	Academic Months	Summer Months	Requested Salary ($)*	Fringe Benefits ($)*	Funds Requested ($)*
1 . Dr.	Cory		Miller		PI		[redacted] percent effort			15,962.00	6,098.00	22,060.00

Total Funds Requested for all Senior Key Persons in the attached file

Additional Senior Key Persons: File Name: **Total Senior/Key Person** **22,060.00**

B. Other Personnel

Number of Personnel*	Project Role*	Calendar Months	Academic Months	Summer Months	Requested Salary ($)*	Fringe Benefits*	Funds Requested ($)*
	Post Doctoral Associates						
	Graduate Students						
	Undergraduate Students						
	Secretarial/Clerical						
1	Veterianarian	[redacted] percent effort			17,065.00	7,850.00	24,915.00
1	Animal Technician Sr				51,537.00	23,707.00	75,244.00
2	**Total Number Other Personnel**					**Total Other Personnel**	**100,159.00**
						Total Salary, Wages and Fringe Benefits (A+B)	**122,219.00**

RESEARCH & RELATED Budget {A-B} (Funds Requested)

Funding Opportunity Number: RFA-MH-20-145 . Received Date: 2019-10-03T16:24:07.000-04:00

RESEARCH & RELATED BUDGET - SECTION C, D, & E, Budget Period 4

ORGANIZATIONAL DUNS*: 8043557900000

Budget Type*: ❍ Project ● Subaward/Consortium

Organization: The Regents of the University of California, U.C. San Diego

Start Date*: 07-01-2023 **End Date*:** 06-30-2024 **Budget Period: 4**

C. Equipment Description

List items and dollar amount for each item exceeding $5,000

Equipment Item	**Funds Requested ($)***
1 . Cages	17,538.00
Total funds requested for all equipment listed in the attached file	
Total Equipment	**17,538.00**

Additional Equipment: File Name:

D. Travel	**Funds Requested ($)***
1. Domestic Travel Costs (Incl. Canada, Mexico, and U.S. Possessions)	
2. Foreign Travel Costs	
Total Travel Cost	**0.00**

E. Participant/Trainee Support Costs		**Funds Requested ($)***
1. Tuition/Fees/Health Insurance		
2. Stipends		
3. Travel		
4. Subsistence		
5. Other:		
Number of Participants/Trainees	**Total Participant Trainee Support Costs**	**0.00**

RESEARCH & RELATED Budget {C-E} (Funds Requested)

RESEARCH & RELATED BUDGET - SECTIONS F-K, Budget Period 4

ORGANIZATIONAL DUNS*: 8043557900000
Budget Type*: ❍ Project ● Subaward/Consortium
Organization: The Regents of the University of California, U.C. San Diego

Start Date*: 07-01-2023 **End Date*:** 06-30-2024 **Budget Period: 4**

F. Other Direct Costs	Funds Requested ($)*
1. Materials and Supplies	
2. Publication Costs	
3. Consultant Services	
4. ADP/Computer Services	
5. Subawards/Consortium/Contractual Costs	
6. Equipment or Facility Rental/User Fees	
7. Alterations and Renovations	
8 . Breeding Colony Housing Costs & Annual Health Exams and Tests	217,841.00
9 . Animal Purchases & Transportation	10,000.00
10 . Telecommunications	1,486.00
Total Other Direct Costs	**229,327.00**

G. Direct Costs	Funds Requested ($)*
Total Direct Costs (A thru F)	**369,084.00**

H. Indirect Costs

Indirect Cost Type	Indirect Cost Rate (%)	Indirect Cost Base ($)	Funds Requested ($)*
1 . MTDC on Campus Rate	58.0	351,544.00	203,896.00
		Total Indirect Costs	**203,896.00**

Cognizant Federal Agency (Agency Name, POC Name, and POC Phone Number) DHHS, Region IX, 415-437-7820

I. Total Direct and Indirect Costs	Funds Requested ($)*
Total Direct and Indirect Institutional Costs (G + H)	**572,980.00**

J. Fee	Funds Requested ($)*

K. Total Costs and Fee	Funds Requested ($)*
	572,980.00

L. Budget Justification* File Name: BudgetJustification.pdf
(Only attach one file.)

RESEARCH & RELATED Budget {F-K} (Funds Requested)

Tracking Number: GRANT12945120
Funding Opportunity Number: RFA-MH-20-145 . Received Date: 2019-10-03T16:24:07.000-04:00

OMB Number: 4040-0001
Expiration Date: 10/31/2019

RESEARCH & RELATED BUDGET - SECTION A & B, Budget Period 5

ORGANIZATIONAL DUNS*: 8043557900000

Budget Type*: ○ Project ● Subaward/Consortium

Enter name of Organization: The Regents of the University of California, U.C. San Diego

Start Date*: 07-01-2024 **End Date*:** 06-30-2025 **Budget Period:** 5

A. Senior/Key Person

Prefix	First Name*	Middle Name	Last Name*	Suffix	Project Role*	Base Salary ($)	Calendar Months	Academic Months	Summer Months	Requested Salary ($)*	Fringe Benefits ($)*	Funds Requested ($)*
1 . Dr.	Cory		Miller		PI		[redacted] percent effort			16,601.00	6,524.00	23,125.00

Total Funds Requested for all Senior Key Persons in the attached file

Additional Senior Key Persons: File Name: **Total Senior/Key Person** **23,125.00**

B. Other Personnel

Number of Personnel*	Project Role*	Calendar Months	Academic Months	Summer Months	Requested Salary ($)*	Fringe Benefits*	Funds Requested ($)*
	Post Doctoral Associates						
	Graduate Students						
	Undergraduate Students						
	Secretarial/Clerical						
1	Veterianarian	[redacted] percent effort			17,576.00	8,314.00	25,890.00
1	Animal Technician Sr				53,083.00	25,108.00	78,191.00
2	**Total Number Other Personnel**					**Total Other Personnel**	**104,081.00**
						Total Salary, Wages and Fringe Benefits (A+B)	**127,206.00**

RESEARCH & RELATED Budget {A-B} (Funds Requested)

Funding Opportunity Number: RFA-MH-20-145 . Received Date: 2019-10-03T16:24:07.000-04:00

RESEARCH & RELATED BUDGET - SECTION C, D, & E, Budget Period 5

ORGANIZATIONAL DUNS*: 8043557900000

Budget Type*: ❍ Project ● Subaward/Consortium

Organization: The Regents of the University of California, U.C. San Diego

Start Date*: 07-01-2024 **End Date*:** 06-30-2025 **Budget Period: 5**

C. Equipment Description

List items and dollar amount for each item exceeding $5,000

Equipment Item	**Funds Requested ($)***
1 . Cages	18,064.00
Total funds requested for all equipment listed in the attached file	
Total Equipment	**18,064.00**

Additional Equipment: File Name:

D. Travel	**Funds Requested ($)***
1. Domestic Travel Costs (Incl. Canada, Mexico, and U.S. Possessions)	
2. Foreign Travel Costs	
Total Travel Cost	**0.00**

E. Participant/Trainee Support Costs		**Funds Requested ($)***
1. Tuition/Fees/Health Insurance		
2. Stipends		
3. Travel		
4. Subsistence		
5. Other:		
Number of Participants/Trainees	**Total Participant Trainee Support Costs**	**0.00**

RESEARCH & RELATED Budget {C-E} (Funds Requested)

RESEARCH & RELATED BUDGET - SECTIONS F-K, Budget Period 5

ORGANIZATIONAL DUNS*: 8043557900000
Budget Type*: ❍ Project ● Subaward/Consortium
Organization: The Regents of the University of California, U.C. San Diego

Start Date*: 07-01-2024 **End Date*:** 06-30-2025 **Budget Period: 5**

F. Other Direct Costs	Funds Requested ($)*
1. Materials and Supplies	
2. Publication Costs	
3. Consultant Services	
4. ADP/Computer Services	
5. Subawards/Consortium/Contractual Costs	
6. Equipment or Facility Rental/User Fees	
7. Alterations and Renovations	
8 . Breeding Colony Housing Costs & Annual Health Exams and Tests	227,983.00
9 . Animal Purchases & Transportation	10,000.00
10 . Telecommunications	1,530.00
Total Other Direct Costs	**239,513.00**

G. Direct Costs	Funds Requested ($)*
Total Direct Costs (A thru F)	**384,783.00**

H. Indirect Costs

Indirect Cost Type	Indirect Cost Rate (%)	Indirect Cost Base ($)	Funds Requested ($)*
1 . MTDC on Campus Rate	58.0	366,719.00	212,697.00
		Total Indirect Costs	**212,697.00**

Cognizant Federal Agency DHHS, Region IX, 415-437-7820
(Agency Name, POC Name, and POC Phone Number)

I. Total Direct and Indirect Costs	Funds Requested ($)*
Total Direct and Indirect Institutional Costs (G + H)	**597,480.00**

J. Fee	Funds Requested ($)*

K. Total Costs and Fee	Funds Requested ($)*
	597,480.00

L. Budget Justification* File Name: BudgetJustification.pdf
(Only attach one file.)

RESEARCH & RELATED Budget {F-K} (Funds Requested)

Tracking Number: GRANT12945120
Funding Opportunity Number: RFA-MH-20-145 . Received Date: 2019-10-03T16:24:07.000-04:00

Budget Justification

Personnel:

- Cory Miller, PhD. (P.I.; Years 1-5: [redacted]) will be responsible for overseeing the day-to-day progress of the west coast breeding colony, as well as management of coordinating efforts with the Johns Hopkins facility to maximize breeding and distribution of the animals.
- Veterinarian (Years 1-5, [redacted]). One of the UCSD Veterinarians will commit to effort on this project. S/he will be responsible for overseeing the care and well being of the animals.
- Colony Manager (Years 1-5: [redacted]). We will recruit an individual with expertise in animal care and management to head the day-to-day operations of the breeding colony. S/he will be responsible for maintaining all health related details for all marmosets in the colony as well as shipments of marmosets to and from the facility.

Other Direct Costs:

Breeding Colony Housing Costs.
We request support for the cages housing breeding pairs in the Breeding Colony. This colony will begin with 12 pairs in Year 1 and increase by 10 pairs in Year 2 and another 8 in Year 3. By year 3, we will be at our goal of 30 breeding pairs. This number of pairs will remain constant for the remaining years of the grant period. The per diem housing cost for a marmoset cage in FY2020 is $16.00/day and increases by 5% annually.

Year 1 : 12 cages: $70,089
Year 2 : 22 cages : $134,921
Year 3 : 30 cages : $193,182
Year 4 : 30 cages : $202,841
Year 5 : 30 cages : $212,983

Annual Health Exams and Tests.
We request support for the ongoing health exams and clinical tests [e.g. Klebsiella, Tuberculosis and Giardia] needed for the Breeding Colony. These will amount to $500/cage/year.

Animal Purchases.
Adult animals will be purchased from the Miller lab (UCSD) and Wang lab (JHU) for $5000/animal to offset the costs associated with housing and rearing the animals in the respective colonies. We will purchase 12 marmosets in Year 1 to establish the breeding colony [$60,000]. 10 animals will then be purchased in Year 2 [$50,000], 8 animals in Year 3 [$40,000], and 4 animals will be purchased in Years 4 and 5 [Y4-5: $40,000]. $3,000 will be paid to the UCSD or JHU lab for these animals to offset the costs of these animals to those labs. We also request funding to support the transportation of these animals to the JHU Breeding Center ($10,000/year). In Year 1, animals will be purchased from the Miller lab directly. Thereafter, we will purchase animals from both UCSD and JHU.

Telecommunications.

UC San Diego Information and Technology Services (ITS) charges a flat per month fee for services to provide state-of-the-art technology infrastructure and services to the campus community. These charges are directly attributable and proportionally applied for the individual(s) included in the proposed budget on the project.

These costs are not included in the campus' Facilities & Administration (F&A) rate as an indirect cost. UC San Diego auditors have determined that it is both equitable and consistent with the OMB Circular 2 CFR 200 provisions on cost allocability that the costs be assigned to FTE on grant and contract funds. Accordingly, an allocable portion of these NGN costs are included in this budget as direct project costs.

Note: Expenses after Year-1 are increased by 3% per annum to allow for inflation raises.

Equipment:

Caging.
We request funding to purchase 15 custom marmoset cages Year 1, 12 cages in Year 2, 8 cages in Year 3, and 3 cages in Years 4 and 5. For each 10 cages used to house the breeding pairs, 2 additional cages are needed to cage transfers during cage cleaning and to allow for individual animals to be housed separately should health or behavioral issues arise within a single cage. In Year 4, give cages will be used for the breeding animals and 1 for these other functions. The cost for a single marmoset cage to be manufactured by the UCSD Machine Shop is $5,350/cage in FY2020 and increases by 3% annually.

Indirect Costs:

UC San Diego's indirect costs are calculated based on Modified Total Direct Costs (MTDC) as defined in 2 CFR Part 200.68 using Facilities and Administration (F&A) rates approved by the U.S. Department of Health and Human Services (DHHS).

Rates established by UC San Diego's F&A rate agreement dated May 23, 2018 are as follows:

July 1, 2020, to June 30, 2021: 57.5%
July 1, 2021, until amended: 58.0%

RESEARCH & RELATED BUDGET - Cumulative Budget

	Totals ($)	
Section A, Senior/Key Person		103,294.00
Section B, Other Personnel		486,267.00
Total Number Other Personnel	10	
Total Salary, Wages and Fringe Benefits (A+B)		589,561.00
Section C, Equipment		227,385.00
Section D, Travel		0.00
1. Domestic	0.00	
2. Foreign	0.00	
Section E, Participant/Trainee Support Costs		0.00
1. Tuition/Fees/Health Insurance	0.00	
2. Stipends	0.00	
3. Travel	0.00	
4. Subsistence	0.00	
5. Other	0.00	
6. Number of Participants/Trainees	0	
Section F, Other Direct Costs		1,083,236.00
1. Materials and Supplies	0.00	
2. Publication Costs	0.00	
3. Consultant Services	0.00	
4. ADP/Computer Services	0.00	
5. Subawards/Consortium/Contractual Costs	0.00	
6. Equipment or Facility Rental/User Fees	0.00	
7. Alterations and Renovations	0.00	
8. Other 1	876,016.00	
9. Other 2	200,000.00	
10. Other 3	7,220.00	
Section G, Direct Costs (A thru F)		1,900,182.00
Section H, Indirect Costs		968,938.00
Section I, Total Direct and Indirect Costs (G + H)		2,869,120.00
Section J, Fee		0.00
Section K, Total Costs and Fee (I + J)		2,869,120.00

Funding Opportunity Number: RFA-MH-20-145 . Received Date: 2019-10-03T16:24:07.000-04:00

Total Direct Costs less Consortium F&A

NIH policy (NOT-OD-05-004) allows applicants to exclude consortium/contractual F&A costs when determining if an application falls at or beneath any applicable direct cost limit. When a direct cost limit is specified in an FOA, the following table can be used to determine if your application falls within that limit.

Categories	Budget Period 1	Budget Period 2	Budget Period 3	Budget Period 4	Budget Period 5	TOTALS
Total Direct Costs less Consortium F&A	985,829	989,039	944,274	930,910	931,688	**4,781,740**

PHS 398 Cover Page Supplement

OMB Number: 0925-0001

Expiration Date: 03/31/2020

1. Vertebrate Animals Section

Are vertebrate animals euthanized? ● Yes ○ No

If "Yes" to euthanasia

Is the method consistent with American Veterinary Medical Association (AVMA) guidelines?

● Yes ○ No

If "No" to AVMA guidelines, describe method and provide scientific justification

2. *Program Income Section

*Is program income anticipated during the periods for which the grant support is requested?

○ Yes ● No

If you checked "yes" above (indicating that program income is anticipated), then use the format below to reflect the amount and source(s). Otherwise, leave this section blank.

*Budget Period	*Anticipated Amount ($)	*Source(s)

Tracking Number: GRANT12945120

Funding Opportunity Number: RFA-MH-20-145 . Received Date: 2019-10-03T16:24:07.000-04:00

PHS 398 Cover Page Supplement

3. Human Embryonic Stem Cells Section

*Does the proposed project involve human embryonic stem cells? ❍ Yes ● No

If the proposed project involves human embryonic stem cells, list below the registration number of the specific cell line(s) from the following list: http://grants.nih.gov/stem_cells/registry/current.htm. Or, if a specific stem cell line cannot be referenced at this time, check the box indicating that one from the registry will be used:

❑ Specific stem cell line cannot be referenced at this time. One from the registry will be used.

Cell Line(s) (Example: 0004):

4. Inventions and Patents Section (Renewal applications)

*Inventions and Patents: ❍ Yes ● No

If the answer is "Yes" then please answer the following:

*Previously Reported: ❍ Yes ❍ No

5. Change of Investigator/Change of Institution Section

❑ Change of Project Director/Principal Investigator

Name of former Project Director/Principal Investigator

Prefix:

*First Name:

Middle Name:

*Last Name:

Suffix:

❑ Change of Grantee Institution

*Name of former institution:

PHS 398 Research Plan

OMB Number: 0925-0001
Expiration Date: 03/31/2020

Introduction	
1. Introduction to Application (for Resubmission and Revision applications)	
Research Plan Section	
2. Specific Aims	SpecificAims_Rev2.pdf
3. Research Strategy*	ResearchStrategy_Rev2.pdf
4. Progress Report Publication List	
Other Research Plan Section	
5. Vertebrate Animals	VertebrateAnimals_Rev2.pdf
6. Select Agent Research	
7. Multiple PD/PI Leadership Plan	
8. Consortium/Contractual Arrangements	
9. Letters of Support	Letters_of_Support.pdf
10. Resource Sharing Plan(s)	Resource_Sharing_Plan.pdf
11. Authentication of Key Biological and/or Chemical Resources	
Appendix	
12. Appendix	

Tracking Number: GRANT12945120
Funding Opportunity Number: RFA-MH-20-145. Received Date: 2019-10-03T16:24:07.000-04:00

Specific Aims

The common marmoset (*Callithrix jacchus*) has experienced unprecedented growth in research across the United States and is rapidly emerging as a likely keystone biomedical model system in the next chapter of scientific discovery. Over the past decade, the number of marmoset laboratories in the US has quadrupled. There are now over 40 Principal Investigators who use marmoset as the model system in their research, according to a recent survey by the first U.S. Marmoset Principal Investigators meeting organized by Drs. Cory Miller (UCSD) and Kuo-fen Lee (Salk Institute) that took place in Boulder, Colorado on September 26th & 27th, 2018 with about 30 PIs attending. This meeting resulted in the 2019 Marmoset Community White Paper – www.marmohub.org - that highlighted the most significant needs for the community. Neuroscience is the primary engine driving marmoset research today, as nearly three quarters of marmoset researchers in the US use this model species to examine molecular, systems or cognitive functions in normal and diseased brains. In contrast to institutional investments in other countries for marmoset research – most notably in Japan – the emergence of marmosets in the US has been driven almost entirely by investigator-initiated projects. Although these grassroots have been successfully forged new paths of scientific inquiry using marmosets in the U.S., critical bottlenecks have emerged that threaten to thwart the continued growth of this emerging model system. A recent survey of marmoset investigators found that the most significant limitation to marmoset research is the availability of animals. There are currently no adequate commercial or academic suppliers of marmosets in the United States.

We propose to establish a Bicoastal Marmoset Breeding Center, with two breeding colonies, one on the East Coast at Johns Hopkins University (JHU) and the other on the West Coast at University of California at San Diego (UCSD). The Center aims to produce a large number of marmosets to supply the marmoset research community in the U.S. Because of the non-availability of air transport of NHP in U.S. and prohibitively expensive ground transportation of NHP between the east and west coast, these two breeding colonies are strategically located to support the marmoset community in regions near each colony. We believe such a center is needed to address the national shortage of marmosets in order for the marmoset model to realize its full potential as a keystone species in the next chapter of neuroscience that serves to accelerate the rate of discovery and better understand human neurological disease. The proposed breeding program under this aim will take the advantage of the extensive experience in managing successful breeding colonies at both JHU and UCSD.

Aim 1. Establish a Bicoastal Marmoset Breeding Center to supply animals to marmoset research community

We propose to establish a Bicoastal Marmoset breeding Center with two breeding facilities – one on the East coast (JHU) and one on the West Coast (UCSD) of the United States – to supply marmosets to the burgeoning community. These two breeding facilities receive strong institutional supports and are strategically located in areas with existing and emerging marmoset laboratories. The two facilities will be led respectively by two experienced marmoset researchers (Xiaoqin Wang at JHU and Cory Miller at UCSD) whose laboratories have a long track record in marmoset research. Transporting NHPs is nearly cost-prohibitive because only land shipment options are currently available. The proposed breeding center is designed to address this issue by optimizing shipments of marmosets around the country. We will coordinate the efforts of the two facilities to optimize animal production, genetic diversity and distributions under the guidance of the Marmoset Coordination Center to be funded by a related NIH RFA (RFA-MH-20-150).

At the conclusion of the proposed research, a minimum of 346 marmosets will be available nationally for research. The impact of these animals on the field of neuroscience research will be significant; and importantly, will improve genetic diversity of the US marmoset population. In addition, the proposed research will foster development of techniques for genetic manipulation in this species. These animals and the resources and techniques developed during the course of the proposed studies will help to elevate and advance neurodevelopmental research.

Research Strategy

A. Significance

A1) Marmosets are an emerging model system for biomedical research

The common marmoset (*Callithrix jacchus*) is a New World monkey that has been used as a model system in biomedical research for several decades. Although marmosets had been used in diverse areas of research, until recently only a handful of investigators actively used the species, which was generally regarded as a niche model system. In less than a decade, however, this landscape has dramatically changed in the United States. Whereas there were 7 marmoset colonies in the US in 2008, by 2018 there were 28. This represents a 4-fold increase, with most of the increase occurring since 2013 (Figure 1). Notably, several of these colonies serve multiple Investigators and there are presently over 45 Principal Investigators currently using marmosets in biomedical research in the United States. This rate of expansion for a nonhuman primate model is unprecedented and reflects the central role that marmosets will play in the next chapter of biomedical research in the United States. To support the rapidly growing demands for marmosets, it is imperative that significant, strategic investments be made so that the model is able to realize its vast potential to transform biomedical research in the decades to come. The first U.S. Marmoset Principal Investigators meeting was organized by Drs. Cory Miller (UCSD) and Kuo-fen Lee (Salk Institute) and took place in Boulder, Colorado on September 26-27, 2018 with about 30 PIs attending, a reflecting of a rapidly growing community. This meeting resulted in the 2019 Marmoset Community White Paper – www.marmohub.org - that highlighted the most significant needs for the community. We identified that the number one priority for the marmoset community was addressing the shortage of animals available for research use in the United States. A second meeting has already been scheduled for April 9th & 10th, 2020 at the same location, again organized by Drs. Miller and Lee. Initial feedback indicates that attendance is expected to increase.

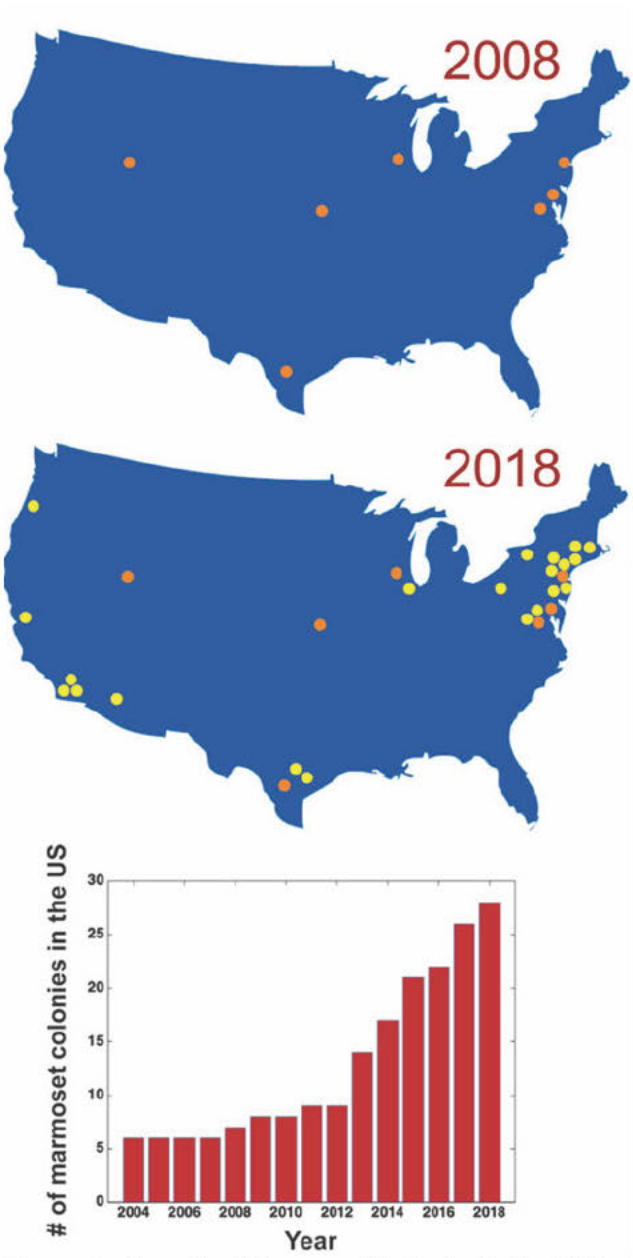

Figure 1. Growth of Marmoset Colonies in the United States. [Top] The schematic maps of the US show the marmoset research colonies [above] in 2008 in orange dots, while [Middle] plots the new colonies in yellow dots that have been established through 2018. [Bottom] Bar graph plots the # of marmoset colonies by year for the past 15 years. Notably, most of the growth in has occurred since 2013.

Several physiological and logistical advantages of marmosets have been crucial to the species rapid emergence over the past few years. For example, marmosets have a gestation of only ~150 days and typically birth fraternal twins, which establishes marmosets as having amongst the highest fertility of any primate (Tardif et al. 2003). Likewise, marmoset development is notably rapid – reaching adulthood in ~14-18 months and becoming aged at ~8yo (Yamamoto 1993, Schiel and Souto 2017). Like rodents, marmosets are small – weighing ~300-400g – and large populations can be housed in smaller facilities than larger primates. However, unlike rodents, marmosets exhibit the shared physiological, behavioral and cognitive characteristics that are unique to primates, including the core functional architecture and organization of our nervous system (Miller et al. 2017). This unique complement of characteristics affords the exciting opportunity to feasibly

utilize a primate species to model many of the diseases that afflict humans, ranging from those that affect humans at specific times in life – including both developmentally and during aging – to neuropsychiatric disorders that impact uniquely primate properties of our brain. The advantages of marmosets are translating to an increasing number of research projects utilizing these animals. According to NIH Reporter, there are currently 49 funded projects being supported by over $40M in funding from 11 NIH ICs and the Office of the Director. Without a significant investment in breeding and distributing animals, there growth of the pivotal biomedical animal model will thwart its potential.

A pivotal cornerstone in the emergence of the marmoset model has been the realization that these characteristics could be feasibly leveraged with the species advantages for next-generation molecular technologies to make unprecedented advances in human disease. Much of the growth in marmosets occurred following the first report of germline transmission of a green fluorescence protein transgene in marmosets by Erika Sasaki and colleagues (Sasaki et al. 2009). Further development of viral and transgenic technologies in marmosets has cemented marmosets at the center of this transformative research enterprise (Sato et al. 2016, Park et al. 2016, Watakabe et al. 2017, Watakabe et al. 2015, Sadakane et al. 2015, Dimidschtein et al. 2016, MacDougall et al. 2016, Santisakultarm et al. 2016, Nurminen et al. 2018).

A2) Advantages of Marmosets for Brain Research

Marmosets have been used as animal models in biomedical research across a diversity of disciplines for several decades (Mansfield 2003, Orsi et al. 2011). Although species has the potential as a cornerstone model in many scientific disciplines, the most common use in the United States today is in studies of molecular and systems neuroscience (Kishi et al. 2014, Mitchell et al. 2014, Marshall and Ridley 2003, Miller et al. 2016), underscoring the need to bolster the species availability for neuroscience. Indeed, Dr. Xiaoqin Wang (PI) pioneered the use of marmosets for systems neuroscience research in the US, as the first investigator to apply modern neuroscientific recording approaches to this species over 20 years ago and has remained at the vanguard of the field. We discuss below some of the key advantages that marmosets have for further utilization in brain research.

High Reproductive Power

Common marmosets produce 2-3 offspring every 5-6 months – the highest fertility of any anthropoid primate (Tardif et al. 2003). This high fertility is a major advantage over any other nonhuman primate species typically used in research, enabling high-speed population expansion, within 3-5 years in comparison to decades. It is a specific advantage for technologies, such as transgenics, in which rapid establishment of genetically defined lines is essential. As an example, 10 macaque breeding females will, in two years' time, have produced a maximum of 20 offspring, all of which will be immature; i.e, the reproductive population will not have increased during that time. In contrast, in the same 2-year period, 10 marmoset breeding females will have produced an average of 60 offspring and the reproductive population will have tripled, as marmosets reach reproductive maturity by 14-18 months of age. While application of transgenic technologies to nonhuman primates will likely remain an expensive enterprise when compared to rodents, the use of marmosets brings this technology within an acceptable financial range for applications in which the nonhuman primate is a particularly compelling model, such as Alzheimer's disease (AD), Parkinson's disease (PD), and other neurodegenerative diseases. Furthermore, the efficiency of *in vitro* fertilization of oocytes (100/collection/animal) is very high (>50%), making marmosets highly economical and scalable for generating the number of genetically modified marmosets needed for preclinical evaluation.

Small Body Size, Fast Maturation and Short Life Span

Adult common marmosets weigh 300-400 grams – meaning they are about the size of a laboratory rat. Their small size makes them easier to handle than large-bodied monkeys and allows for spacious, social housing in a relatively small laboratory space. Owing to their small size, marmosets require limited amounts of test compounds when used to study vaccines, therapeutics or other interventions – a decided advantage when test material is in limited quantities.

Many of the most pressing U.S. human health concerns involve diseases that emerge early in development, are chronic or for which aging is a strong risk factor. The fast maturation and relatively short life span of marmosets makes them a valuable resource to study developmental, chronic and aging related diseases. Marmosets are sexually mature at 14-18 months of age and display signs of age-related pathologies – such as β-amyloid accumulation in the brain (Rodriguez-Callejas et al. 2016), impaired cochlear function and lean mass loss - by 8-13 years of age. Most importantly, the time period required to move from early to late life – i.e. to

advance through the stages of development, aging or chronic disease - is within the range of a typical, NIH-funded project (i.e. 5 year R01 grant). Furthermore, like humans, marmosets are typically group-housed with pair-bonded parents and 2 generations of offspring, making it possible to observe the process of aging across three generations of animals in the same cage. This is a particularly attractive feature for transgenic models in which disease onset may depend on aging factors, such as neurodegenerative disorders like AD and PD (Colman 2018, Tardif et al. 2011).

Brain Architecture and Function

While marmosets have a rat-like body size, they have a primate-typical brain size of 2% of body weight. The rat brain, in contrast, is 0.5% of their body weight. The marmoset brain comprises the core brain architecture unique to – and shared by - all primates, including humans (Solomon and Rosa 2014, Chaplin et al. 2013). This includes a large neocortex, granular prefrontal cortex – a substrate unique to the primate brain (Laubach 2018) – reduced olfactory regions and an expansion of the visual and auditory cortical fields. Furthermore, marmoset cortex is lissencephalic (smooth) which offers a significant logistical advantage to neuroscientific inquiry as the entirety of the neocortical fields are accessible directly below the skull, rather than within sulci.

The marmoset brain shares many of the unique primate specializations evident in humans, thus offering the opportunity to expand our understanding of brain function relevant to human mental health and disease. Furthermore, new experimental opportunities are rooted in marmosets' gregarious social behavior, which, together with their relative ease in handling and breeding, invite investigation into interactive and developmental aspects of primate cognition. Marmosets are particularly well suited for studying the brain in paradigms involving interactive social behavior. Several aspects of their behavior resemble that of humans, including their cooperative foraging and defense, reciprocal communication, and biparental rearing of offspring. The marmoset's brain shares many of its primate features with the human brain, including specializations for social perception and vocal communication. These scientific factors, together with practical considerations such as the relative ease in breeding and handling marmosets compared to macaques, opens the door to a range of naturalistic experimental paradigms. Recent advances in miniaturization and telemetry make it possible to measure and manipulate brain circuits during natural social exchanges, such as affiliative, competitive, and reproductive behaviors. Taken together, the marmoset affords unique opportunities to investigate new dimensions of primate brain functions relevant to mental health and disease.

Further, the marmoset is an ideal species for studying mechanisms of prenatal and postnatal brain development relevant to mental illness. Similar to other primates, marmoset brain development diverges from other mammals by the inclusion of additional zones of neural progenitors, the preservation of neural stem cells after birth, and an unusually protracted childhood during which the brain matures slowly amid abundant social experience. The systematic investigation into the anatomy and physiology of primate brain development and its bearing on cognition, from the cellular and molecular processes in the embryo to the brain's circuit development during critical periods in early life, requires high level control over a species' reproductive biology, breeding, rearing, and weaning. Marmosets breed easily in captivity and can be housed in multigenerational families that cooperate in the rearing of infants. Moreover, marmosets exhibit routine twinning, typically with two reproductive cycles each year, with offspring reaching sexual maturity at the age of eighteen months. Together, these factors provide a much-needed opportunity to study unique features of primate brain development whose failure is suspected to be at the core of psychiatric disorders.

Social Behavior, Cognition and Communication

Primates are distinguished from other animals by the breadth and sophistication of our sociality, including the dynamic models we develop for social decision-making to effectively navigate the complexities of these social landscapes. While marmosets share these attributes with other primates, their societies also exhibit characteristics that are typical of humans yet rare in other primates (Miller et al. 2016). Marmosets, for example, pair-bond and cooperatively care for their offspring (Schiel and Souto 2017). Cooperation occurs frequently in marmoset society and the species displays high levels of prosociality (Burkart et al. 2009). Several experiments show that marmosets also utilize imitation, a distinct social learning mechanism that is rare amongst primates as it has only been reported in humans and chimpanzees (Voelkl and Huber 2007). Marmosets are also highly vocal, engaging in near tonic levels of conversational exchanges with conspecifics by utilizing turn-taking mechanisms that are learned during development (Eliades and Miller 2017). While vocal communication is critical to mediating their social interactions, marmosets also utilize a diverse corpus of visual signals – including facial expressions – as a parallel social signaling system, similarly to humans (Miller et al. 2016). More generally, marmosets' complex behavior and inquisitive nature make them a model of interest for a broader set of questions

in high level cognition. As such, marmoset allow for studying the interplay between cognitive, emotional and motivational processes, as well as their modulation by internal state factors such as stress, and how these may fall apart in mental health disorders.

Availability of Transgenic Marmosets for Experimental Studies

The rapid emergence of marmosets for neuroscience research over the past decade has occurred in large part due to the species' advantages for developing and implementing modern gene-editing technologies in a nonhuman primate. Indeed, much of the growth in marmosets occurred following the first report of germline transmission of a transgene in a nonhuman primate by Erika Sasaki and colleagues in 2009. Since that time, intense investment in developing modern molecular technologies in marmosets has accelerated (Sato et al. 2016, Park et al. 2016, Watakabe et al. 2017, Watakabe et al. 2015), including the development of a transgenic marmoset line expressing a genetically encoded calcium indicator (Sadakane et al. 2015) and the first successful implementation of CRISPR technology to develop Cre lines in marmosets (Dr. Guoping Feng at MIT, personal communication). At present, there are at least five Institutions that are making considerable investments to develop transgenic marmoset lines in the United States (MIT, Johns Hopkins, NIMH, Salk Institute, University of Pittsburgh). In contrast to analogous efforts in rodents, however, there is currently no existing system to breed and disseminate the forthcoming transgenic lines to the broader scientific community. The Breeding and Resource Center proposed here is uniquely suited to meet this emerging need in the next phase of work. The proposed Bicoastal Breeding Center is not only able to provide a critical resource to the neuroscience community immediately – wild marmosets for experimental use – but is uniquely positioned and planning for the dissemination of a forthcoming technology: transgenic marmoset lines.

A3) Marmosets as a Model of Human Neuropsychiatric Disease

The collective objective of the Marmoset research community to leverage the benefits of this NHP model system in order to accelerate our knowledge of the genetic, physiological and environmental factors underlying human disease. While a diversity of animal models has significantly contributed to our general knowledge of the cellular and molecular basis of disease in biological systems, precisely how these processes unfold within the uniquely primate physiology remains sorely under studied. All of the Community Priorities and Recommendations focus on establishing essential resources and infrastructure necessary for marmosets to bridge this considerable gap and realize the model's potential as a keystone organism in biomedical research for the next generation.

The non-human primate of choice for studying mechanisms of brain function has traditionally been the macaque. However, the common marmoset represents a complementary species with advantageous characteristics for studying a range of human disease. First, the marmoset has strong reproductive power. Macaques reach sexual maturity after ~5 years and give birth once a year to a single offspring. Rhesus and cynomolgus macaques typically live 25 years and can live up to 30 and 40 years in captivity, respectively. This lifespan presents a number of logistical challenges for longitudinal studies of age-related disorders, including neurodegenerative diseases. In contrast, marmosets reach sexual maturity at 18 months of age, and females give birth twice a year, usually to non-identical twins or triplets. Based on average birth rates, to obtain 400 offspring from 50 breeding females, it would take 6 years in marmosets and 20 years in rhesus macaques. Furthermore, the efficiency of *in vitro* fertilization of oocytes (100/collection/animal) is very high (>50%), making marmosets highly economical and scalable for generating the number of genetically modified marmosets needed for preclinical evaluation. Second, because of marmosets' small body size, they can be housed in social groups consistent with the size and composition of groups in the wild. This is particularly important because the range of sophisticated social and cognitive behaviors that emerge naturally within social groups – and that are shared with humans (Miller et al. 2016, Mitchell and Leopold 2015) - can be effectively studied under more controlled laboratory conditions. This makes them ideal for modeling the broad range of human aging, neurodegenerative and psychiatric disorders that ultimately require a primate model due to the idiosyncrasies of the primate brain organization and function. Studies of neurogenic syndromes such as Williams syndrome (Crespi and Procyshyn 2017, Procyshyn et al. 2017), Rett Syndrome (Katz et al.2016), Fragile X syndrome (Niu et al. 2017), autism (Shank3 mutations) (Pagani et al. 2019) and Syngap mutations (Clement et al. 2012) could benefit greatly from transgenic NHP models.

Furthermore, since marmosets can be housed in their natural social group, the anxiety, depression, and social withdrawal common amongst laboratory housed rhesus macaques (Camus et al. 2013) does not emerge. Because these behaviors are atypical of marmosets in laboratories, genetic models of psychiatric disorders will not be confounded by these environmental factors. Third, in contrast to rhesus macaques, marmosets are free of Herpes B viruses, making the species safer to work with. Finally, technologies for generating transgenic

marmosets have already been developed, and their short generation time represents a distinct advantage for creating and expanding transgenic lines over larger nonhuman primate species.

A4) Challenges and Opportunities for Marmosets in Neuroscience Research

Bottleneck #1: Severe shortages of marmoset supplies in U.S.

The most commonly cited bottleneck for research from our survey was the availability of animals for research. This crucial bottleneck has occurred because there are currently no reliable distributors of marmosets for biomedical research in the country. Among seven National Primate Research Centers, two currently have marmoset colonies (Wisconsin and Southwest NPRC), but only one of them (Southwest) sells marmosets to outside investigators (current waiting time is longer than 2-3 years). There are presently ~1900 marmosets in the US across 28 identified research colonies in the United States. However, nearly every investigator surveyed during 2018 Marmoset PI meeting noted that their colony was smaller than they ideally needed for their research and most PIs felt their colony would ideally be about double its current size. Importantly, this total represents only current marmoset users. Given the growth of marmoset labs throughout the country, this number will surely increase accordingly. Furthermore, whereas most existing labs currently perform neuroscience research and require relatively small colonies (~25-50 animals), marmosets are only beginning to bridge into areas of research that traditionally require large numbers of animals, such as the development of genetic models, infectious disease, and drug addiction. In order to facilitate the use of marmosets in these areas, significantly larger populations available for sale are needed. We recommend an immediate and significant investment to rapidly expand strategic marmoset populations for use in US biomedical research. In addition, we recommend support devoted to the maintenance of aging colonies, as the development of aging research in this model depends on the availability of older animals. Furthermore, we recommend that national breeding centers be strategically placed along the East and West coasts of the US near Universities and Institutes that currently support marmoset research, or are likely to in the near future in order to reduce the substantial shipping costs associated with transporting nonhuman primates across the country (e.g., ~$12,000 per shipment by air-conditioned ground transportation from East coast to West coast). In short, the dearth of available marmosets in the US remains the most significant bottleneck for research and will need to be resolved for the model system to continue to expand. The proposed bicoastal breeding center will address this issue (**Aim 1**). One advantage of the proposed bi-costal breeding center with two colonies on the east and west coasts, respectively, is that it would substantially save individual investigators cost of shipping animals across the country.

Bottleneck #2: Genetic diversity of existing domestic marmoset populations

The existing marmoset populations in the US come from unknown origins, but it is speculated based on limited genealogical records that many are from a single source in Europe. This presents challenges because it necessitates that a more concrete strategic plan be implemented to both expanding marmoset populations and managing existing populations over time in order to increase the genetic diversity in the U.S. marmoset population. Given the current size of the US population (~1900 animals), it will be necessary to both optimize diversity amongst these animals as well as seek out avenues to introduce new genes into the population. We plan to pursue actions to introduce entirely different genetic stock from that currently in the US marmoset population, either through physically adding new animals into the population or through artificial insemination methods from those other populations. This effort will likely be an invaluable cornerstone to a diversity of research areas in the coming years. To this end, we will also work closely with the Marmoset Coordination Center to be funded by NIH (per RFA-MH-20-150) to strategically genotype the marmoset populations in our colonies and manage the genetic diversity.

Innovation

The concept of a two-site, and especially bicoastal, breeding program is innovative. Although marmoset laboratories are widespread across the U.S., the majority of these labs are located along the east and west coasts of the country (Figure 1). Moreover, most of the top-tier academic institutions are also concentrated in these same areas. Given the high transportation cost to ship NHPs, an integrated network of breeding colonies located close to current and likely future marmoset laboratories can better serve the marmoset research community. Finally, given the long history of breeding marmosets and active research programs in marmosets at both JHU and UCSD, these facilities can serve not only as a breeding center, but as a key resource for optimal marmoset care and husbandry for new and established investigators.

In addition to serving as a resource to improve genetic diversity in the species in general, the proposed research is also innovative because it will provide an infrastructure for creation and distribution of genetically modified marmosets. Our preliminary studies at Johns Hopkins suggest that current ovarian stimulation and in-vitro fertilization procedures in the species can be optimized to improve efficiency and reduce expenses for creation of genetically modified animals. For instance, we were the first to use GnRH antagonists to prevent premature luteinization in the species. The proposed studies will generate information, procedures and genetically modified animals that will have broad interest to the neuroscience research community and facilitate the use of this scarce resource.

B. Approach

B1) The existing marmoset colonies at JHU and UCSD

Overview of JHU marmoset colony:

Dr. Wang established the marmoset colony at Johns Hopkins University School of Medicine in 1995 and has been successfully breeding marmosets since then. Since the inception of our colony, we have maintained a well-managed breeding program and avoided in-breeding. Our breeding program has been highly successful over the past 24 years, with each breeding pair producing on average 3 live offspring per year. Dr. Wang's lab and veterinarians at Johns Hopkins University School of Medicine have worked with marmosets for over 20 years and gained considerable experience in caring this non-human primate species. Over the years, our breeding colony has produced animals used in a number of NIH-funded research projects. Dr. Wang's laboratory has pioneered the marmoset model for behavioral and neurophysiological studies of auditory and vocal functions and has made important contributions to this growing field by developing key behavioral, surgical, and neurophysiological techniques (Wang 2018). They are the first to develop both single neuron extracellular and intracellular recording techniques in awake and behaving marmosets (Lu et al. 2001, Wang et al. 2005), the first to develop wireless neural recording technique with chronically implanted multi-channel electrode arrays in freely moving marmosets (Eliades and Wang, 2008, Roy and Wang 2012) and the first to develop an operant conditioning technique to study marmoset's auditory perceptual behaviors (Remington et al. 2012).

In the past several years, we have initiated a transgenic marmoset program at Johns Hopkins University School of Medicine. With pilot funding from the John Davis Fund at Johns Hopkins, we have assembled a team of investigators to develop transgenic marmoset models for neuropsychiatric and neurodevelopmental disorders. Team members have expertise in marmoset physiology and behaviors (Xiaoqin Wang, PhD, Professor of Biomedical Engineering and Neuroscience), reproductive science (James Segars, MD, Howard and Georgeanna Jones Professor and Director, Division of Reproductive Sciences and Women's Health Research, Department of Gynecology and Obstetrics), neurobiology (Christopher Ross, MD/PhD, Professor of Psychiatry, Neurology Neuroscience and Pharmacology, and Director of the Division of Neurobiology), developmental neuropsychiatry and neuroimaging (James Harris, MD, Professor of Psychiatry and Behavioral Sciences and Pediatrics, and founding director of the Developmental Neuropsychiatry program), behavioral biology (Catherine Davis-Takacs, PhD, Assistant Professor Behavioral Biology), veterinary medicine and molecular and comparative pathobiology (Jessica Izzi, DVM, Assistant Professor of Molecular and Comparative Pathobiology and Director of Large Animal Medicine and Surgery). Working together we are developing pilot data for next steps in developing transgenic marmosets. We seek to study transgenic marmoset models of known neurogenetic syndromes. Currently there is a transgenic marmoset model for Rett Syndrome and a Shank3 autism model (Phelan McDermid syndrome). We plan to collaborate with the investigators who developed the Shank3 model to conduct neurocognitive testing and brain neuroimaging. We are

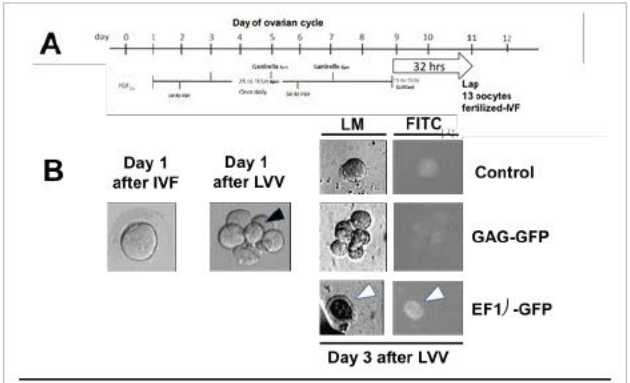

Figure 2. Express on of GFP n marmoset embryos dr ven by EF1a promoter de vered by ent v rus. **A.** *IVF stimulation protocol.* FSH was njected at 25 IU (ne) da y, or FSH 50 IU and gan re x was added on days 4 and 7. 75IU of hCG was g ven on day 9 and oocytes were retr eved 32 hours ater. **B.** Express on of green f uorescence prote n (GFP) n marmoset embryos. The zona pe uc da was removed (b ack arrowhead, moru a) and 1 μ of ent v rus vector (LVV) conta n ng GFP dr ven by e ther GAG or EF1α, or PBS contro , was n 30 μ drop ets. Embryos were observed 3 days and GFP s gna was detected n EF1α-GFP-treated embryo (wh te arrowhead).

interested in exploring a better Rett Syndrome model, a Williams syndrome prosociality gene GTF2 model, an FMRP-regulated gene linked to autism spectrum disorder model and a SYNGAP1-related non-syndromic intellectual disability model.

As an initial step toward development of genetically modified marmosets, we used two different lentiviral vectors driving expression of green fluorescent protein (GFP) and performed in-vitro fertilization in marmosets, in a collaborative program with Erika Sasaki. We modified methods reported by Dr. Sasaki (Sasaki et al., 2009), Dr. James Pickel of NIH (unpublished), existing information regarding marmoset reproduction (Marshall et al. 2003; Tardif et al. 2003; Tomioka et al, 2012; Takahashi et al, 2014; Sasaki et al, 2015; Kurotaki et al., 2017), and information gleaned from our own unpublished experience with embryo retrieval, culture, IVF and ICSI in the marmoset to produce embryos. Lentiviral vectors were prepared in the lab of Dr. Ross, and expression was verified in human and marmoset cell lines. As proof-of-concept, we demonstrated GFP expression 3 days after lentiviral infection into marmoset embryos (Figure 2). The Johns Hopkins marmoset genetics core possesses the equipment necessary for gene manipulation, including ICSI-fluorescent microscope with Narishige micromanipulators, MINC and C02 incubators, and ultrasound. Future studies will focus on gene manipulation for specific neurobehavioral conditions using lentiviral overexpression, Talens, CRISPR-Cas9, or other strategies. Our staff are experienced with embryo cryopreservation using vitrification, which will facilitate sharing of the genetically modified embryos with other centers. Our team possesses expertise for phenotyping and initial characterization of the genetically modified animals, including CANTAB for cognition and other behavioral tests, and is highly experienced in genetic and environmental models of psychiatric and neurodevelopmental conditions (Zhu et al 2017; Waldron-Roby et al 2012; Pletnikov et al 2008; Ayhan et al 2009). We are in the process of generating marmosets with a genetically encoded neuronal activity reporter (GCAMP6) under the control of the CamKII promoter. Other plans or experiments in progress include point mutations in SYNGAP, relevant to autism and intellectual disability (Araki et al 2015; Kilinc et al 2018), conditional loss of function alterations in ANK3 relevant to bipolar disorder (Zhu et al 2017), alterations of C4A complement, relevant to schizophrenia and other disorders (Sekar et al 2016), and possibly expansion of the CAG repeat in Huntingtin, relevant to Huntington's disease. The current proposal will enhance infrastructure for these projects (which will be funded separately), and will provide resources for distribution of models generated.

We have strong veterinary expertise from our leading department on Molecular and Comparative Pathobiology which will allow us to provide expert veterinary care for transgenic marmosets with disorders. Special care will be needed to care transgenic marmosets so veterinary expertise is essential. Dr. Jessica Izzi (co-I of this application) has extensive experience in working with marmosets both at NIH and JHU.

JHU Census. JHU colony currently has 199 marmosets, 155 are 1.5 years or older. Over the past two years, we deliberately increased our colony size in anticipation of the national needs for the marmosets by the research community and to support our own growing transgenic marmoset program.

JHU Colony Distribution. There 50 active breeders (25 breeding pairs), 79 being on hold as potential future breeders, 45 experimental animals, 25 potential future experimental animals. The experimental animals are used in invasive or non-invasive protocols.

JHU Pedigree. The animals in the JHU colony are from different sources. Over the past 24 years, we have periodically purchased marmosets from various sources to diversify genetic background of the animals in the colony. confidential/proprietary

[redacted]

Overview of UCSD marmoset colony:

Dr. Miller established his marmoset colony at UC San Diego in October 2009 and has been successfully breeding this population since 2010. Over the past 10 years, we have regularly maintained 4-5 breeding pairs and maintained the population at ~40 animals. This size has been sufficient for the research needs of Sr. Miller's laboratory. Over the past 18 months, we deliberately increased our colony size by eliminating the birth control measures and increasing the number of breeding pairs to 8-10. Our breeding program has been highly successful. Our breeding pairs have averaged 3.1 offspring per year, with each pair typically birthing 1-2 pairs of babies each calendar year.

UCSD Census. At present, the UCSD colony comprises 64 animals. The UCSD colony currently comprises 13 separate cages. Ten of these cages house a male/female pair and 1-3 generations of offspring. The remaining three cages house same-sex pairs of animals that have been implanted with electrodes for neurophysiological experiments. The colony comprises 34 animals that are >1 year of age, the remaining 30 are under this age.

UCSD Colony Distribution. Presently, 14 of the adult animals in the UCSD colony are involved in non-invasive behavioral experiments, while four adult animals are being used in neurophysiological experiments. All ten of the cages housing Male/Female pairs are actively engaged in breeding. Our protocol does not currently distinguish between breeding and non-invasive behavioral experiments, as some of the breeding animals are also used in behavioral studies of vocal communication.

UCSD Pedigree. The animals in the UCSD colony are from several different sources. confidential/proprietary [redacted]

B2) The infrastructure available for the marmoset colony

JHU:

The JHU colony is currently located in the animal facility on School of Medicine East Baltimore campus where Dr. Wang's lab is located, with a total of 1,728 Sq ft animal housing space. We have been approved for an additional 644 Sq ft space to house more animals for this breeding program, with a total of 2,374 Sq ft which is sufficient to house the proposed number of marmosets. The Director of Animal Resources has agreed to allocate additional space for this breeding program as the colony size grows (please see the letter from Dr. Eric Hutchinson in the Appendix). The additional spaces are located on Bayview campus of JHU School of Medicine, about 2.8 miles from the East Baltimore campus, within an existing large-animal housing facility and serviced by Animal Care Services of JHU. JHU has a large, well-established AAALAC-accredited animal care program. We plan to start the breeding colony with 20 breeding pairs in Year-1, add 10 more breeding pairs in Year-2 and Year-3 each, to reach a total of 40 breeding pairs by the end of Year-3. We plan to maintain 40 active breeding pairs for Year-4 and Year-5. We plan to obtain initial breeding pairs from the existing colony at JHU.

UCSD:

Dr. Miller's laboratory does not have sufficient colony space to expand his breeding capabilities in the same location to meet the planned size of the Breeding Center. As a result, the Breeding Center will be located at the UCSD Elliot Field Station. This research facility is located ~10 miles east of the main UCSD campus and managed by the UCSD Animal Care Program. The entire site consists of 26.8 acres and comprises 14 buildings that are used to house animals for research. Marmosets have regularly been housed at this location following the acquisition of animals from external sources. 3000 sq ft are available at the UCSD Elliot Field Station for this breeding project. We will be allocated 1000sq ft in year 1, 2000 in year 2 and the full space by year 3 to accommodate the growing colony size. Dr. Phil Richter - the Chair of the UCSD Animal Care Program has committed to providing us the space for this project. This amount of space will be sufficient for the planned size of the Breeding Center at UCSD (please see the letter from Dr. Sandra Brown in the Appendix). All the animal facilities at UCSD are AALAC accredited. We plan to obtain initial breeding pairs from the existing colonies at UCSD and JHU.

Please see below the breeding production table.

JHU					**# Animals to sell**	
Year	New breed ng pa rs	Tota breed ng pa rs	Offspr ng (<1yr o d)	Offspr ng (>1yr o d)	**Offspring (>1.5yr old)**	Program Income ($)
1	20	20	20	0	**0**	0
2	10	30	60	20	**10**	30,000
3	10	40	80	60	**40**	120,000
4	0	40	80	80	**70**	210,000
5	0	40	80	80	**80**	240,000

UCSD					**# Animals to sell**	
Year	New breed ng pa rs	Tota breed ng pa rs	Offspr ng (<1yr o d)	Offspr ng (>1yr o d)	**Offspring (>1.5yr old)**	Program Income ($)
1	12	12	12	0	**0**	0
2	10	22	44	12	**6**	18,000
3	8	30	60	44	**28**	84,000
4	0	30	60	60	**52**	156,000
5	0	30	60	60	**60**	180,000

Table 1. Calculations of breeding production and marmoset distributions. Notes: (1) Number of offspring (Column-4) is calculated as 2 per year per breeding pair for Years 2-5. This is a conservative and safe estimate given that the average number of live births in both JHU and UCSD colonies has been ~3 per year per breeding pair. We reduce this number to 1 per year per breeding pair for Year-1 since the new breeding colonies need time to settle and breeders may not reach full breeding capacity. (2) The number in Column-5 (offspring > 1 year old) is equal to the previous year's number in Column-4. (3) The number of marmosets to distribute each year (Column-6, >1.5 years old) is equal to ½ of animals in Column-5 of previous two years (e.g., Year-3: (20+60)/2=40). (4) Marmosets will be sold at a price of $3,000 per animal. The program income in each year is equal to the number in Column-6 multiplied by the sale price.

B3) Plans to distribute marmosets to the neuroscience research community

(1) Current distribution

JHU Current distribution. Over the past 20 years, we have distributed marmosets to multiple institutions across the country confidential/proprietary JHU Animal Services has a license for non-human primate sales (including marmosets). The preference has been given to young independent investigators who started new marmoset laboratories.

UCSD Current distribution. We have distributed animals to several other laboratories since the lab was formed. In the past three years, we have utilized a MTA [Material Transfer Agreement] mechanism to facilitate distribution of animals to other Institutions. This approach was adopted because we were distributing relatively small number of animals. However, we have successfully used this approach to send animals to confidential/proprietary To enable larger scale distribution of animals associated with this award, we would obtain a license for animal sales. The UCSD Animal Care Program currently has such a license for rodents and the chair of the program – Dr. Phil Richter – has agreed to apply for a marmoset license should we receive this award.

JHU+UCSD Annual Distributions	# Animals
Year-1	0
Year-2	16
Year-3	68
Year-4	122
Year-5	140
Years 1-5	**346**
Total # animals Distributed by Award End	# Animals
JHU	200
UCSD	146
JHU+UCSD	**346**

Table 2. Marmoset distributions from JHU and UCSD colonies. The numbers are based on calculations in Table 1.

(2) Future distribution

If this application is awarded, we will modify existing distribution systems in both JHU and UCSD to accommodate the requests that originate from the Marmoset Coordination Center. Table 2 above shows the estimated number of marmosets to be distributed by the proposed Bicoastal Breeding Center.

B4) Efforts to focus on questions related to animal husbandry

As part of this award, Johns Hopkins University will continue to build upon its record of conducting and publishing original research regarding marmoset husbandry and clinical care. We have previously received funding from the American College of Laboratory Animal Medicine (ACLAM) Foundation for studying and have published extensively upon the diagnosis and treatment of idiopathic enterocolitis and bone disease commonly referred to as “Marmoset Wasting Syndrome” (Baxter et al. 2013, Otovic et al. 2015, Olson et al. 2015). We have published reports on a number of other colony and individual health concerns in marmosets (Pisharath et al. 2005, Wachtman et al. 2006, Werts et al. 2019). We currently have an active project examining the appetite stimulating effects of midazolam in and out of anxiogenic conditions, supported via our ACLAM certified veterinary training program in laboratory animal medicine. We [redacted] private support for an ongoing project examining the microbiome changes associated with international transportation, idiopathic diarrhea, and acclimation into a new colony. In addition to these marmoset specific projects, JHU veterinary faculty and ACLAM trainees have an extensive history of publications looking at questions of husbandry, transport, welfare, and clinical care in a number of other species, the equipment, techniques, and expertise for which could easily be applied to similar questions focusing upon marmosets. These projects have been and will continue to be supported by departmental funds supporting the ACLAM training program.

In addition to taking part in collaborative projects as recommended by the Marmosets for Neuroscience Steering Committee, we would propose to explore several specific questions regarding marmoset husbandry and transportation. First, as part of our dual-site proposal, we would be uniquely situated to and would carry out experiments exploring the effects of short- and long-distance marmoset transport on several markers of physical health and psychological well-being, including the microbiome (building upon our current project), hair cortisol, hematologic values, and breeding performance. Our veterinary faculty and trainees have previous experience with all of these assays, and we would plan to support their use through departmental training funds made available for ACLAM trainee projects. Additionally, we will continue to explore novel therapies and prophylactics for idiopathic enterocolitis and bone disease in marmosets, efforts which are already ongoing as we explore how to optimize perinatal calcium balance in marmosets.

B5) Program Income

If awarded, both JHU and UCSD colonies will provide marmosets to the research community starting from Year-2 (please see Table 2). A new Order page will be added to www.marmohub.org for researchers to request animals. We expect to distribute a total of 346 marmosets from this program over the awarded period (JHU colony: 200 marmosets, UCSD colony: 146 marmosets) in accordance with our Resource Sharing Plan. We plan to sell marmosets at weaning age (>1.5 years old) to individual investigators or institutions at a price of $3,000/ea (please see Table 1 for anticipated annual program income). This price is substantially lower than the price of marmosets currently being sold by various sources such as commercial vendors and National Primate Centers (>$6,500/ea). The reason for us to sell marmosets at this relatively low price is to make the animals more affordable to investigators who want to start or transition their scientific careers using this model system, especially young independent investigators. We believe this is critical to boost marmoset research in the United States.

We plan to use the program income in the following ways to support the proposed project for the objectives as stated in RFA-MH-20-145 for this award:

1) To hire additional personnel to help manage this breeding program. Both JHU and UCSD colonies will need to add a veterinary technician after Year-1 when the size of the colonies begins to grow. Due to the overall budget limit, we could not include this cost in this application. Each colony plans to hire a veterinary technician at 50% effort in Year-2 and 100% in Years 3-5.
2) We plan to purchase marmoset breeders from external sources (colonies in other universities or National Primate Centers) that have different genetic lineages from the breeders in both colonies to broaden the

genetic diversity. We expect to purchase ~5 pairs of breeders each year in Years 3-5 at an estimated cost between $70,000-$100,000 per year (purchase: >$6,000/ea x 10 animals; transportation: >$1,000/ea x 10 animals, much higher if imported from outside U.S.). We may also swap animals between JHU and UCSD colonies to diversify the genetic background and use the program income to pay for transportations.

3) We plan to use program income to supplement colony care expenses. The per diem rates are currently relatively low at both JHU and UCSD (substantially lower than most US institutions). However, both colonies need to cover some expenses in animal care which will likely increase as the size of the colonies to grow.
4) In addition, we plan to use JHU program income to support the transgenic marmoset program at JHU from which we will gain valuable experience in breeding and caring transgenic marmosets and their offspring.

B6) Timeline and Milestone

Year-1: Establish a dedicated breeding colony for the proposed breeding programs at both JHU and UCSD, with a total of 32 breeding pairs (JHU: 20, UCSD: 12, see Table 1).

Year-2: Increase the colony size to 30 (JHU) and 22 (UCSD) breeding pairs. We will begin to distribute marmosets to the research community. We expect to sell 10 marmosets from JHU colony and 6 marmosets from UCSD colony that are older than 1.5 years.

Year-3: Increase the colony size to 40 (JHU) and 30 (UCSD) breeding pairs. We expect to sell 40 marmosets from JHU colony and 28 marmosets from UCSD colony that are older than 1.5 years.

Year 4: Maintain the colony size at 40 (JHU) and 30 (UCSD) breeding pairs. Replace non-productive breeding pairs if needed. We expect to sell 70 marmosets from JHU colony and 52 marmosets from UCSD colony that are older than 1.5 years.

Year 5: Maintain the colony size at 40 (JHU) and 30 (UCSD) breeding pairs. Replace non-productive breeding pairs if needed. We expect to sell 80 marmosets from JHU colony and 60 marmosets from UCSD colony that are older than 1.5 years.

The total number of marmosets distributed to the research community are estimated at 346 (Y2: 16, Y3: 68, Y4: 122, Y5: 140, see Table 2).

B7) Team Management Plan

Dr. Xiaoqin Wang (PI) at JHU will be responsible for the oversight and coordination of project management as well as the work performed in the breeding colony at JHU. Dr. Wang has more than 20 years of experience in directly managing one of the largest marmoset breeding programs in the United States and experience in managing a large DARPA research project (as the Lead PI) that involves teams from multiple universities. Dr. Wang is well known by the marmoset research community in the world.

Dr. Cory Miller (co-I) at UCSD will be responsible for work performed in the breeding colony at UCSD. Dr. Cory Miller has a long history of working with NHPs including tamarins and marmosets. He has also played a leadership role in organizing marmoset neuroscience research community in the United States.

Dr. Jessica Izzi (co-I) at JHU will be responsible for the oversight of all animal health and husbandry issues in both colonies. She will work closely with veterinarians at UCSD. Dr. Izzi is the Director of Large Animal Medicine and Surgery at Johns Hopkins University and has extensive experience in working with marmosets.

Drs. Wang, Izzi and Miller will closely coordinate activities at the two colonies. They will communicate weekly, either by phone, e-mail, or in person, to discuss colony management, breeding, animal care and distribution and all administrative issues. All PIs will share their respective research results and information with other PIs, key personnel, and consultants. They will work together to discuss any changes in the direction of the project and the reprogramming of funds, if necessary. Dr. Wang will serve as contact PI and be responsible for submission of progress reports to NIH and all communication. Drs. Wang, Izzi and Miller will maintain close communication with the Marmoset Coordination Center and the Project Scientist(s) from NIH.

PHS Human Subjects and Clinical Trials Information

OMB Number: 0925-0001 and 0925-0002

Expiration Date: 03/31/2020

Are Human Subjects Involved	❍ Yes ● No
Is the Project Exempt from Federal regulations?	❍ Yes ❍ No
Exemption Number	❑ 1 ❑ 2 ❑ 3 ❑ 4 ❑ 5 ❑ 6 ❑ 7 ❑ 8
Does the proposed research involve human specimens and/or data	❍ Yes ● No
Other Requested information	

Vertebrate Animals (JHU)

1. Proposed use of animal

We propose to use common marmosets (*Callithrix jacchus*) in this study. The proposed research has been approved by the Johns Hopkins University Animal Use and Care Committee (Protocol# PR18M345). We plan to house up to 250 marmosets each year in the proposed breeding program.

2. Procedures

A breeding colony of marmosets has been maintained at JHMI Animal Facility since 1995. Marmosets reach sexual maturity around 18 months of age. We usually pair a male and a female as a breeder at 1.5-2 years of age. They typically begin breeding 6-12 months after being pair-housed (in a large family cage). Marmosets typically give births twice a year. The offspring usually stays with parents in the family cage till they are one year old. Breeding takes place naturally in the colony. Breeding pairs are housed in family cages where offspring stays with parents till they reach ~1 year of age. Young adult marmosets will be pair-housed with the same sex partner after they are removed from their natal families at approximately 1 year of age until they reach approximately 1.5-2 years of age when they are either pair-housed with an opposite sex partner to form a new breeding pair or pair-housed with a same sex partner if they are used in experimental protocols.

Descriptions of routine care, caging and husbandry, clinical monitoring, blood sampling, etc.

Animals in our colony are either singly-housed, pair-housed (as juveniles or breeding pairs), or in large family cages with up to 3 litters. Animals are pair-housed whenever possible. Singly-housed or pair-housed animals consist of study animals with protocol-related exemptions or animals that do not have a suitable conspecific available. Juveniles are weaned between 1.5-2 years of age. Visual health checks are conducted a minimum of once daily by animal care staff and any clinical concerns are reported directly to the veterinary staff. Animals are fed LabDiet 5LK6 Callitrichid Diet once daily and are offered a variety of feed enrichment at least 3x per week. Chlorinated water is provided in bottles that are changed daily. Non-edible enrichment consists of wooden sticks, huts, forage boards, and other toys. Non-edible enrichment and cages are sanitized every 2 weeks on alternating schedules.

All animals in the colony are weighed every two weeks and weights are recorded and tracked in an excel sheet. Any concerning weight trends are reported to the veterinary staff.

Animals receive a full routine physical examination with blood work (CBC and chemistry) and full body radiographs once per year. Additional clinical monitoring is performed when warranted based on health concerns noted by technical staff, care staff, or veterinarians when animals are scheduled to start on study or undergo surgery. Fecal samples are submitted as indicated to test for pathogens such as *Giardia spp., Klebsiella pneumonia, Salmonella,* and *Campylobacter spp.* Additional diagnostics are performed by veterinary staff as indicated, including but not limited to abdominal ultrasound, cystocentesis, and bone marrow biopsy. A veterinarian is present to either assist with or perform all surgical procedures.

Description of how large litters are managed:

Upon birth, the dam and infants are hand-caught and the infants are weighed and examined by a veterinarian for any congenital defects or other concerns. The dam is checked to confirm lactation and to confirm that the uterus is empty (no additional fetuses or placenta present). If the animal gives birth to more than 2 infants, the additional infants are either cross-fostered, hand-reared, or euthanized. Typically, the smallest infant is chosen and/or the infant is chosen based on sex (for instance, if 2 males and 1 female are born, 1 male may be chosen to remove from family group). The veterinarian will determine the fate for each infant based on available fosters in the colony or ability to hand-rear successfully. In most cases, hand-rearing is only chosen if the animal is extremely valuable (i.e. transgenic marmoset). A foster family is chosen based on good rearing history and having recently given birth (dam is actively nursing or lactating). Foster family should either have a singleton or no infants.

Birth control of the breeding females:

Because of considerations of a particular breeding family's health condition, we sometimes need to control the rate of births of certain breeding pairs. Estrumate, a synthetic prostaglandin analog structurally related to PGF2α, will be used to control reproduction in breeding pairs on a protocol adapted from one used by the Wisconsin Regional Primate Research Center for their colony of captive-bred common marmosets. Giving a PGF2α analog disrupts the corpus luteum in pregnant females, resulting in a loss of support for early

pregnancy. There are no documented long-term effects (physical or behavioral) and as soon as treatment is halted, normal pregnancy can occur at the next regular estrus cycle. Benefits include keeping the family units together, slowing down the increase in colony size, and allowing the breeding female's body to replenish itself. The PGF2α analog will be administered in early pregnancy, detected by manual uterine palpation and determined by uterine diameter standard measurements derived by WRPRC. The uterine palpation will be done in awake, hand restrained, breeding females and, if uterine diameter indicates early pregnancy, Estrumate will be administered via IM injection. The standard dose is 0.75μg PGF2α analog given once intramuscularly. The animal may be checked after 3 to 4 days for decrease in uterine diameter. For resistant pregnancies the dose is increased to 1.0μg PGF2α analog given IM once daily for two days. The process is repeated every 4 to 6 weeks. The considered alternatives to using a PGF2α analog included separation of mates, causing extreme stress among all group members; oophorectomy in breeding females, an permanent and invasive procedure with many possible physical complications and disruption of the family unit (breeding females inhibit estrus in submissive females through scent marking and it is unknown what effect lack of estrogen may have on this process); vasectomy in the breeding male, also a very invasive procedure, possibly permanent, which is difficult in such a small species; and an implant birth control device in the breeding female, a method used widely in captive nonhuman primate species but which is not feasible in the common marmoset because of the very small amount of proper tissue in which to place the implant.

3. Justification of the use of animals

The common marmoset is the ideal nonhuman model for neuroscience. The species is amenable to functional neuroimaging techniques commonly used in humans, but can also be studied with various invasive neurophysiological procedures. The marmoset is particularly suitable for the following reasons: 1) the species' exhibits a rich repertoire of cognitively sophisticated behaviors that typify primates, as well as social cognitive behaviors – such as imitation and prosociality - which are rare amongst nonhuman primates but characteristic of human sociality 2) it is one of a few primate species that can be easily bred in captivity (not an endangered species) and easy to handle (body weight 300-500g), and 3) the species has an almost entirely lissencephalic (smooth) cortex, making all areas of cortex much easier to access experimentally than many other primate species.

4. Veterinary Care

The veterinary care will be provided by the Research Animal Resources (RAR) department at JHU (AAALAC accredited), which is very experienced in caring primates including marmosets. RAR provides central support service for animal procurement, housing, clinical care, and veterinary research support and collaboration at Johns Hopkins University campuses, including the East Baltimore medical school campus, Homewood campus, and Bayview campus. The department is overseen by 4 faculty veterinarians with ACLAM board certification. In addition, RAR provides post-doctoral training for veterinarians specializing in laboratory animal medicine.

5. Procedure to Limit Pain and Discomfort

There are no experimental procedures to be performed to the animals in this project. If a surgery is needed for clinical reasons, a long acting anesthetic (0.5% Marcaine) will be used to infiltrate the wound. This will be helpful in reducing postprocedural pain. A continuous, powerful, short acting anesthetic (isoflurane) for titration of anesthesia to an areflexic level. The anesthetic level (withdraw and corneal reflexes) and heart and respiratory rates will be monitored continuously by a second experimenter not involved in surgery. Isoflurane administration will be adjusted to areflexia and to maintain the heart and respiratory rates at the baseline values. Postoperatively, Buprenorphine (0.005mg/kg) will be given subcutaneously to further minimize pain and discomfort. After the surgery, the animal will be evaluated daily by the veterinarians and lab staffs until it fully recovers. Veterinary consultation will be requested to advise treatment, should any problems arise.

6. Method of Euthanasia

When an animal needs be euthanized for clinical reasons, it will be first sedated by ketamine (IM, 20mg/kg) and then euthanized with a lethal dose of intravenous sodium pentobarbital (IP, 150mg/kg), followed by intracardial perfusion with a 4% paraformaldehyde (to preserve the brain tissue for histology). This is a fast and effective method that has been successfully used in many small New World primates, including marmosets, and is consistent with the recommendations of the Panel on Euthanasia of the American Veterinary Medical Association (AVMA).

Vertebrate Animals (UCSD)

1. Proposed use of animal

We propose to use the common marmosets (Callithrix jacchus) in this project. We propose to build the size of the breeding colony from 12 pairs to 30 pairs over the course of 5 years. I have successfully bred marmosets in my own laboratory since 2010. Over that time, breeding pairs have averaged ~3 infants a year. My laboratory currently houses over 60 marmosets for use in our experiments. We have 10 active breeding pairs in the colony.

2. Justification of the use of animal

The common marmoset is the ideal nonhuman model for neuroscience. The species is amenable to functional neuroimaging techniques commonly used in humans, but can also be studied with various invasive neurophysiological procedures. The marmoset is particularly suitable for the following reasons: 1) the species' exhibits a rich repertoire of cognitively sophisticated behaviors that typify primates, as well as social cognitive behaviors – such as imitation and prosociality - which are rare amongst nonhuman primates but characteristic of human sociality 2) it is one of a few primate species that can be easily bred in captivity (not an endangered species) and easy to handle (body weight 300-500g), and 3) the species has an almost entirely lissencephalic (smooth) cortex, making all areas of cortex much easier to access experimentally than many other primate species.

3. Veterinary Care

The veterinary care will be provided by the Animal Care Program at P.I.'s institution (AAALAC accredited) which is very experienced in caring primates. The P.I. has already established a marmoset colony that has been housed in the laboratory for over a year and has received excellent care by the UCSD veterinarian and animal care staff.

4. Procedure to Limit Pain and Discomfort

There are no experimental procedures to be performed to the animals in this project. If a surgery is needed for clinical reasons, a long acting anesthetic (0.5% Marcaine) will be used to infiltrate the wound. This will be helpful in reducing postprocedural pain. A continuous, powerful, short acting anesthetic (isoflurane) for titration of anesthesia to an areflexic level. The anesthetic level (withdraw and corneal reflexes) and heart and respiratory rates will be monitored continuously by a second experimenter not involved in surgery. Isoflurane administration will be adjusted to areflexia and to maintain the heart and respiratory rates at the baseline values. Postoperatively, Buprenorphine (0.005mg/kg) will be given subcutaneously to further minimize pain and discomfort. After the surgery, the animal will be evaluated daily by the veterinarians and lab staffs until it fully recovers. Veterinary consultation will be requested to advise treatment, should any problems arise.

5. Method of Euthanasia

When an animal needs be euthanized for clinical reasons, it will be euthanized with a lethal dose of intravenous sodium pentobarbital (150mg/kg) and followed by intracardial perfusion with a glutaradehyde/formaldehyde mixture (to preserve brain tissue for histology). This is a fast and effective method that has been successfully used in many small New World primates including marmoset and is consistent with the recommendations of the Panel on Euthanasia of the American Veterinary Medical Association (AVMA).

References Cited

Araki Y, Zeng M, Zhang M, Huganir RL. Rapid dispersion of SynGAP from synaptic spines triggers AMPA receptor insertion and spine enlargement during LTP. Neuron. 2015, 85:173-189.

Ayhan Y, Abazyan B, Nomura J, Kim R, Ladenheim B, Krasnova IN, Sawa A, Margolis RL, Cadet JL, Mori S, Vogel MW, Ross CA, Pletnikov MV. Differential effects of prenatal and postnatal expressions of mutant human DISC1 on neurobehavioral phenotypes in transgenic mice: evidence for neurodevelopmental origin of major psychiatric disorders. Mol Psychiatry. 2011, 16(3):293-306.

Ayhan Y, Sawa A, Ross CA, Pletnikov MV. Animal models of gene-environment interactions in schizophrenia. Behav Brain Res. 2009, 204(2):274-81.

Burkart JM, Hrdy SB, van Schaik CP. Cooperative breeding and human cognitive evolution. Evolutionary Anthropology. 2009,18:175-86.

Camus SMJ, Blois-Heulin C, Li Q, Hausberger M, Bezard E. Behavioural Profiles in Captive-Bred Cynomolgus Macaques: Towards Monkey Models of Mental Disorders? PLoS ONE. 2013; 8(4):e62141.

Chaplin T, Yu H, Soares J, Gattass R, Rosa MGP. A conserved pattern of differential expansion of cortical areaas in simian primates. J Neurosci. 2013; 18:15120-5.

Clement JP, Aceti M, Creson TK, Ozkan ED, Shi Y, Reish NJ, Almonte AG, Miller BH, Wiltgen BJ, Miller CA, Xu X, Rumbaugh G. Pathogenic SYNGAP1 mutations impair cognitive development by disrupting maturation of dendritic spine synapses. Cell. 2012; 151(4):709-723

Colman RJ. Non-human primates as a model for aging. Biochimica et Biophysica Acta (BBA) - Molecular Basis of Disease. 2018; 1864(9, Part A):2733-41.

Crespi BJ, Procyshyn TL. Williams syndrome deletions and duplications: Genetic windows to understanding anxiety, sociality, autism, and schizophrenia. Neurosci Biobehav Rev. 2017, 79:14-26.

Dimidschtein J, Chen Q, Temblay R, Rogers SL, Saldi G, Guo L, Xu Q, Liu RC, Lu C, Chu J, Avery M, Rashid M, Baek M, Jacob A, Smith G, Wilson D, Kosche G, Kuglikov I, Rusielwicz T, Kotak V, Mowery T, Anderson S, Callaway EM, Dasen J, Fitzpatrick D, Fossati V, Long MA, Noggle S, Reynolds JH, Sanes DH, Rudy B, Feng G, Fishell G. A viral strategy for targeting and manipulating interneurons across vertebrate species. Nature Neuroscience. 2016; 19:1743-9.

Eliades SJ, Miller CT. Marmoset vocal communication: Neurobiology and behavior. Developmental Neurobiology. 2017; 77:286-99.

Eliades SJ, Wang X. Neural substrates of vocalization feedback monitoring in primate auditory cortex. Nature. 2008, 453:1102-6.

Katz DM, Bird A, Coenraads M, Gray SJ, Menon DU, Philpot BD, Tarquinio DC. Rett Syndrome: Crossing the Threshold to Clinical Translation. Trends Neurosci. 2016;39(2):100-113.

Kilinc M, Creson T, Rojas C, Aceti M, Ellegood J, Vaissiere T, Lerch JP, Rumbaugh G. Species-conserved SYNGAP1 phenotypes associated with neurodevelopmental disorders. Mol Cell Neurosci. 2018; 91:140-150.

Kishi N, Sato K, Sasaki E, Okano H. Common marmoset as a new model animal for neuroscience research and genome editingtechnology. Dev Growth Differ. 2014; 56(1):53-62.

Kurotaki, Y. and E. Sasaki, Practical Reproductive Techniques for the Common Marmoset. Journal of Mammalian Ova Research, 2017, 34(1): 3-12.

Laubach M, Amarante LM, Swanson K, White SR. What, If Anything, Is Rodent Prefrontal Cortex? eneuro. 2018; 5(5):ENEURO.0315-18.2018.

Lu, T., L. Liang and X. Wang. Temporal and rate representations of time-varying signals in the auditory cortex of awake primates. Nat Neurosci, 4:1131-1138, (2001)

MacDougall M, Nummela SU, Coop S, Disney AA, Mitchell JF, Miller CT. Optogenetic photostimulation of neural circuits in awake marmosets. J Neurophys. 2016;116:1286-94.

Mansfield K. Marmoset models commonly used in biomedical research. Comp Med. 2003;53(4):383-92.

Marshall JW1, Ridley RM. Assessment of cognitive and motor deficits in a marmoset model of stroke. ILAR J. 2003; 44(2):153-60.
Marshall, V.S., et al., Ovarian stimulation of marmoset monkeys (Callithrix jacchus) using recombinant human follicle stimulating hormone. J Med Primatol, 2003. 32(1): 57-66.
Miller CT, Freiwald W, Leopold DA, Mitchell JF, Silva AC, Wang X. Marmosets: A Neuroscientific Model of Human Social Behavior. Neuron. 2016; 90:219-33.
Mitchell JF, Leopold DA. The marmoset monkey as a model for visual neuroscience. Neuroscience Research. 2015; 93:20-46.
Niu M, Han Y, Dy ABC, Du J, Jin H, Qin J, Zhang J, Li Q, Hagerman RJ. Autism Symptoms in Fragile X Syndrome. J Child Neurol. 2017; 32(10):903-909.
Nurminen L, Merlin S, Bijanzadeh M, Federer F, Angelucci A. Top-down feedback controls spatial summation and response amplitude in primate visual cortex. Nature Communications. 2018; 9(1):2281.
Okano, H., et al., Brain/MINDS: A Japanese National Brain Project for Marmoset Neuroscience. Neuron, 2016. 92(3): 582-590.
Orsi A, Rees D, Andreini I, Venturella S, Cinelli S, Oberto G. Overview of the marmoset as a model in nonclinical development of pharmaceutical products. Regul Toxicol Pharmacol. 2011; 59(1):19-27.
Pagani M, Bertero A, Liska A, Galbusera A, Sabbioni M, Barsotti N, Colenbier N, Marinazzo D, Scattoni ML, Pasqualetti M, Gozzi A. Deletion of Autism Risk Gene Shank3 Disrupts Prefrontal Connectivity. J Neurosci. 2019; 39(27):5299-5310.
Park JE, Zhang XF, Choi S, Okahara J, Sasaki E, Silva AC. Generation of transgenic marmosets expressing genetically encoded calcium indicators. Scientific Reports. 2016; 6:34931.
Pletnikov MV, Ayhan Y, Xu Y, Nikolskaia O, Ovanesov M, Huang H, Mori S, Moran TH, Ross CA. Enlargement of the lateral ventricles in mutant DISC1 transgenic mice. Mol Psychiatry. 2008;13(2):115.
Procyshyn TL, Spence J, Read S, Watson NV, Crespi BJ. The Williams syndrome prosociality gene GTF2I mediates oxytocin reactivity and social anxiety in a healthy population. Biol Lett. 2017;13(4)
Remington ED, Osmanski MS, Wang X. An operant conditioning method for studying auditory behaviors in marmoset monkeys. PLoS ONE 7(10): e47895 (2012)
Rodriguez-Callejas JD, Fuchs E, Perez-Cruz C. Evidence of Tau Hyperphosphorylation and Dystrophic Microglia in the Common Marmoset. 2016;8(315). doi: 10.3389/fnagi.2016.00315.
Sadakane O, Masamizu Y, Watakabe A, Terada S, Ohtsuka M, Takaji M, Mizukami H, Ozawa K, Kawasaki H, Matsuzaki M, Yamamori T. Long-term Two-photon Calcium Imaging of neuronal populations with subcellular resolution in adult non-human primates. Cell reports. 2015; 13:1989-99.
Santisakultarm TP, Kresbergen CJ, Bandy DK, Ide DC, Choi S, Silva AC. Two-photon imaging of cerebral hemodynamics and neural activity in awake and anesthetized marmosets. Journal of Neuroscience Methods. 2016; 271:55-64.
Sasaki E, Suemizu H, Shimada A, Hanazawa K, Oiwa R, Kamioka M, Tomioka I, Sotomaru Y, Hirakawa R, Eto R, Siozawa S, Maeda T, Ito M, Ito R, Kito C, Yagihashi C, Kawai K, Miyoshi H, Tanioka Y, Tamaoki N, Habu S, Okano H, Nomura T. Generation of transgenic non-human primates with germline transmission. Nature. 2009; 459:523-7.
Sasaki, E., Prospects for genetically modified non-human primate models, including the common marmoset. Neurosci Res, 2015. 93:110-5.
Sato K, Oiwa R, Kumita W, Henry R, Sakuma T, Ryoji I, Nozu R, Inoue T, Katano I, Sato K, Okahara N, Okahara J, Shimizu Y, Yamamoto M, Hanazawa K, Kawakami T, Kametani Y, Suzuki R, Takahashi TT, Weinstein E, Yamamoto T, Sakakibara Y, Habu S, Hata J, Okano H, Sasaki E. Generation of a nonhuman primate model of severe combined immunodeficiency using highly efficient genome editing. Cell stem cell. 2016; 19:127-38.
Sato, K. and E. Sasaki, Genetic engineering in nonhuman primates for human disease modeling. J Hum Genet, 2018. 63(2):125-131.

Schiel N, Souto A. The common marmoset: An overview of its natural history, ecology and behavior. Developmental Neurobiology. 2017; 77:244-62.

Sekar A, Bialas AR, de Rivera H, Davis A, Hammond TR, Kamitaki N, Tooley K, Presumey J, Baum M, Van Doren V, Genovese G, Rose SA, Handsaker RE; Schizophrenia Working Group of the Psychiatric Genomics Consortium, Daly MJ, Carroll MC, Stevens B, McCarroll SA. Schizophrenia risk from complex variation of complement component 4. Nature. 2016; 530(7589):177-83.

Solomon SG, Rosa MGP. A simpler primate brain: The visual system of the marmoset monkey. Frontiers in Neural Circuits. 2014; 8(96):1-24.

Takahashi, T., et al., Birth of healthy offspring following ICSI in in vitro-matured common marmoset (Callithrix jacchus) oocytes. PLoS One, 2014. 9(4): p. e95560.

Tardif SD, Mansfield KG, Ratnam R, Ross CN, Ziegler TE. The marmoset as a model of aging and age-related disease. ILAR journal/ National Research Council, Institute of Laboratory Animal Resources. 2011; 52:54-65.

Tardif SD, Smucny DA, Abbott DH, Mansfield K, Schultz-Darken N, Yamamoto ME. Reproduction in captive common marmosets (Callithrix jacchus). Comparative Medicine. 2003; 53:364-8.

Tardif, S.D., et al., Reproduction in captive common marmosets (Callithrix jacchus). Comp Med, 2003. 53(4): 364-8.

Tomioka I, Takahashi T, Shimada A, Yoshioka K, Sasaki E. Birth of common marmoset (Callithrix jacchus) offspring derived from in vitro-matured oocytes in chemically defined medium. Theriogenology, 2012. 78(7): 1487-93.

Voelkl B, Huber L. Imitation as faithful copying of a novel technique in marmoset monkeys. PLoS ONE. 2007; 2(7):e611.

Waldron-Roby E, Ratovitski T, Wang X, Jiang M, Watkin E, Arbez N, Graham RK, Hayden MR, Hou Z, Mori S, Swing D, Pletnikov M, Duan W, Tessarollo L, Ross CA. Transgenic mouse model expressing the caspase 6 fragment of mutant huntingtin. J Neurosci. 2012; 32(1):183-93.

Wang X. Cortical Coding of Auditory Features. Annu Rev Neurosci. 41:527-552, 2018.

Wang, X., T. Lu, R.K. Snider and L. Liang. Sustained firing in auditory cortex evoked by preferred stimuli. Nature 435: 341-346 (2005).

Watakabe A, Ohtsuka M, Kinoshita M, Takaji M, Isa K, Mizukami H, Ozawa K, Isa T, Yamamori T. Comparative analyses of adeno-associated viral vector serotypes 1,2,5,8, and 9 in marmoset, mouse and macaque cerebral cortex. . Neuroscience Research. 2015; 93:144-57.

Watakabe A, Sadakane O, Hata K, Ohtsuka M, Takaji M, Yamamori T. Application of viral vectors to the study of neural connectivities and neural circuits in the marmoset brain. Developmental Neurobiology. 2017, 77(3):354-372.

Yamamoto M. From dependence to sexual maturity: the behavioural ontogeny of Callitrichidae. In: Rylands AB, editor. Marmosets and Tamarins: Systematics, Behavior and Ecology. London: Oxford University Press; 1993. p. 235-54.

Zhu S, Cordner ZA, Xiong J, Chiu CT, Artola A, Zuo Y, Nelson AD, Kim TY, Zaika N, Woolums BM, Hess EJ, Wang X, Chuang DM, Pletnikov MM, Jenkins PM, Tamashiro KL, Ross CA. Genetic disruption of ankyrin-G in adult mouse forebrain causes cortical synapse alteration and behavior reminiscent of bipolar disorder. Proc Natl Acad Sci U S A. 2017;114(39):10479-10484.

Letters of Support Cover Page

A) Letters of Support from Representative Marmoset Users (PIs):

Guoping Feng (MIT)
Winrich Freiwald (Rockefeller University)
Keren Haroush (Stanford University)
Alexander Huk (UT Austin)
Elias Issa (Columbia University)
David Leopold (NIH)
Jude Mitchell (University of Rochester)
Anirvan Nandy (Yale University)
Yi Zhou (Arizona State University)

B) Letters of Support on Resources:

Sandra Brown (UCSD)
Eric Hutchinson (JHU)

C) Letters of Support from External Consultants:

Kuo-Fen Lee (Salk Institute)
Erika Sasaki (CIEA, Japan)

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Guoping Feng
Investigator, McGovern Institute
Poitras Professor of Neuroscience
Department of Brain and Cognitive
Sciences

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September 28, 2019

Dear Study Section Reviewers

It is my pleasure to enthusiastically support the U24 proposal by Drs. Xiaoqin Wang & Cory Miller titled 'Bicoastal Marmoset Breeding and Resource Center'. Marmosets are rapidly emerging model system in neuroscience, one that is gaining increasing use, exposure, and demand. Unfortunately, one of the most important and significant issues that is threatening the further growth of the model is the lack of availability of animals for research.

Having established a small marmoset breeding colony at MIT, genetic diversity in breeding remains an ongoing issue, both for my lab as well as for many other small laboratories across the country. Creating a centralized breeding resource center to disseminate these animals, critical to our research, would meet a pressing need for my own research program and the broader marmoset community. Integrated breeding centers on the East and West coasts of the US would significantly reduce my costs for transportation and facilitate the rapid distribution of the animals.

As leaders and pioneers in marmoset neuroscience research with extensive experience breeding animals, Drs Wang and Miller are ideally suited to succeed in this endeavor. I wholeheartedly and enthusiastically urge you to strongly consider their proposal at this critical juncture for the future of marmoset research in the United States.

Yours sincerely,

Guoping Feng, PhD
Poitras Professor of Neuroscience
McGovern Institute for Brain Research
Department of Brain and Cognitive Sciences
Massachusetts Institute of Technology

Director of Model Systems and Neurobiology
Stanley Center for Psychiatric Research
Broad Institute of MIT and Harvard

SCIENCE FOR THE BENEFIT OF HUMANITY

Winrich Freiwald
Professor
Laboratory of Neural Systems
p: 212-327-7697
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wfreiwald@rockefeller edu

New York, September 29th, 2019

Dear Colleagues,

Please allow me to submit this letter of support on behalf of the U24 proposal by Drs. Xiaoqin Wang & Cory Miller titled 'Bicoastal Marmoset Breeding and Resource Center'.

Marmosets are rapidly emerging model system in neuroscience, one that is gaining increasing use, exposure, and demand. One of the most important and significant issues that is threatening the further growth of the model is the lack of availability of animals for research. It is for this reason that RFA-MH-20-145 was issued to allow for a few centers to breed and generate transgenic marmoset monkeys for the neuroscience research community was issued by the Brain Initiative. The application, in my view, is the ideal response to RFA-MH-20-145.

It is exciting to me that two leaders and pioneers in marmoset neuroscience with extensive experience breeding animals, Drs Wang and Miller, are submitting this proposal. They are ideally suited to succeed in this endeavor. I urge you to strongly consider their proposal at this critical juncture for the future of marmoset research in the United States!

Yours,

Winrich Freiwald

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Stanford MEDICINE | Department of Neurobiology

September 30, 2019

Dear Study Section Reviewers,

It is my pleasure to enthusiastically support the U24 proposal by Drs. Xiaoqin Wang & Cory Miller titled 'Bicoastal Marmoset Breeding and Resource Center'. Marmosets are rapidly emerging model system in neuroscience, one that is gaining increasing use, exposure, and demand. Unfortunately, one of the most important and significant issues that is threatening the further growth of the model is the lack of availability of animals for research.

When I initially started my lab, I found there was no place to order marmosets and struggled to find sufficient animals to begin my marmoset research lab. As an Assistant Professor, the lack of marmosets in the country continues to be a significant challenge to accomplish my research goals. Even having established a small marmoset breeding colony at Stanford, we still do not have the critical number of animals needed to conduct our research and spark campus wide collaborations. Moreover, genetic diversity in breeding remains an ongoing issue, both for my lab as well as for many other small laboratories across the country. Creating a centralized breeding resource center to disseminate these animals, critical to our research, would meet a pressing need for my own research program and the broader marmoset community. Integrated breeding centers on the East and West coasts of the US would significant reduce my costs for transportation and facilitate the rapid distribution of the animals.

As leaders and pioneers in marmoset neuroscience research with extensive experience breeding animals, Drs Wang and Miller are ideally suited to succeed in this endeavor. I wholeheartedly and enthusiastically urge you to strongly consider their proposal at this critical juncture for the future of marmoset research in the United States.

Sincerely yours,

Keren Haroush, Ph.D.
Assistant Professor
Department of Neurobiology
Stanford University

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CENTER FOR PERCEPTUAL SYSTEMS
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Sept 28, 2019

Dear Study Section Reviewers,

It is my pleasure to enthusiastically support the U24 proposal by Drs. Xiaoqin Wang & Cory Miller titled 'Bicoastal Marmoset Breeding and Resource Center'. Marmosets are rapidly emerging model system in neuroscience, one that is gaining increasing use, exposure, and demand . Unfortunately, one of the most important and significant issues that is threatening the further growth of the model is the lack of availability of animals for research.

Having established a small marmoset breeding colony at The University of Texas at Austin, genetic diversity in breeding remains an ongoing issue, both for my lab as well as for many other small laboratories across the country. Creating a centralized breeding resource center to disseminate these animals, critical to our research, would meet a pressing need for my own research program and the broader marmoset community. Integrated breeding centers on the East and West coasts of the US would significant reduce my costs for transportation and facilitate the rapid distribution of the animals.

As leaders and pioneers in marmoset neuroscience research with extensive experience breeding animals, Drs. Wang and Miller are ideally suited to succeed in this endeavor. I collaborate with Dr. Miller and can attest to his deep commitment to marmoset research and welfare, as well as his ability to manage large-scale projects.

I therefore wholeheartedly and enthusiastically urge you to strongly consider their proposal at this critical juncture for the future of marmoset research in the United States.

Sincerely,

Alexander C. Huk
Raymond Dickson Centennial Professor #2, Depts. of Neuroscience & Psychology
Director, Center for Perceptual Systems
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September 30, 2019

Dear Study Section Reviewers

It is my pleasure to enthusiastically support the U24 proposal by Drs. Xiaoqin Wang & Cory Miller entitled "Bicoastal Marmoset Breeding and Resource Center." Marmosets are a rapidly emerging model system in neuroscience, one that is gaining increasing use, exposure, and demand. The most significant issue threatening the rapidly emerging marmoset model in neuroscience is the availability of animals for research. When I initially started my lab, I benefited greatly from the generosity of Drs. Wang & Miller who both contributed founding animals to start my marmoset colony at Columbia University. Without these donations, I would have been unable to initiate my research program as a new PI because there is a national shortage of marmosets within the US (waitlist times at the national primate centers would have set my research prohibitively back).

Having gone through the process of starting a marmoset lab, I think it is critical that other young investigators have access to marmosets within a reasonable time and at a reasonable cost. Therefore, establishing a centralized breeding resource center to disseminate the animals critical to research would meet a pressing need for my own research and the broader marmoset community by ensuring the availability, quality and genetic diversity of animals (the next challenge for my small lab colony is to maintain genetic diversity in my colony). Integrated breeding centers on the East and West coasts of the US would further reduce my costs for transportation and facilitate rapid distribution of animals. As leaders and pioneers in marmoset neuroscience research, Drs. Wang and Miller are ideally suited to succeed in this endeavor.

I wholeheartedly and enthusiastically urge you to strongly consider their proposal at this critical juncture for the future of marmoset research in the United States.

Sincerely,

Elias Issa

Elias Issa
Assistant Professor
Department of Neuroscience
Columbia University

DEPARTMENT OF HEALTH & HUMAN SERVICES

Pub c Hea th Serv ce

Dav d A. Leopo d, Ph.D.
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September 28, 2019

Dear Study Section Reviewers

It is my pleasure to enthusiastically support the U24 proposal by Drs. Xiaoqin Wang & Cory Miller titled 'Bicoastal Marmoset Breeding and Resource Center'. Marmosets are rapidly emerging model system in neuroscience, one that is gaining increasing use, exposure, and demand. Unfortunately, one of the most important and significant issues that is threatening the further growth of the model is the lack of availability of animals for research.

Having established a small marmoset breeding colony at the National Institute of Mental Health, genetic diversity in breeding remains an ongoing issue, both for my lab as well as for many other small laboratories across the country. Creating a centralized breeding resource center to disseminate these animals, critical to our research, would meet a pressing need for my own research program and the broader marmoset community. Integrated breeding centers on the East and West coasts of the US would significant reduce my costs for transportation and facilitate the rapid distribution of the animals.

As leaders and pioneers in marmoset neuroscience research with extensive experience breeding animals, Drs Wang and Miller are ideally suited to succeed in this endeavor. I wholeheartedly and enthusiastically urge you to strongly consider their proposal at this critical juncture for the future of marmoset research in the United States.

Sincerely,

David Leopold, PhD
Senior Investigator
Laboratory of Neuropsychology
National Institute of Mental Health

UNIVERSITY of ROCHESTER

DEPARTMENT OF
BRAIN AND COGNITIVE SCIENCES

September 28, 2019

Dear Study Section,

I'm writing to enthusiastically support the U24 proposal by Drs. Xiaoqin Wang & Cory Miller titled 'Bicoastal Marmoset Breeding and Resource Center'. Marmosets are rapidly emerging model system in neuroscience, one that is gaining in its use and demand. One critical issue threatening the further growth of the model is the lack of availability of animals for research.

When I initially started my lab five years ago, I had the good fortune to acquire several marmosets from Dr. Miller. Many investigators beginning labs now struggle to find sufficient animals for research. As an Assistant Professor, the lack of marmosets in the country continues to be a significant challenge. Even after having established my own small marmoset breeding colony, genetic diversity remains an ongoing issue for us and requires the acquisition of new animals on a regular basis. Creating a centralized breeding resource center to disseminate these animals would meet a pressing need for my own research program and the broader marmoset community. Further, by having integrated breeding centers on the East and West coasts of the US it would greatly reduce the costs for distribution of the animals to investigators.

As leaders and pioneers in marmoset neuroscience research with extensive experience breeding animals, Drs Wang and Miller are ideally suited to succeed in this endeavor. I strongly support their proposal and believe that it represents a critical juncture for the future of marmoset research in the United States.

Sincerely,

Jude F Mitchell

Jude F. Mitchell, Ph.D.

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Dear Study Section Reviewers

It is my pleasure to enthusiastically support the U24 proposal by Drs. Xiaoqin Wang & Cory Miller titled 'Bicoastal Marmoset Breeding and Resource Center'. The most significant issue threatening the rapidly emerging marmoset model in neuroscience is the availability of animals for research. When I initially started my lab in August of 2017, I found there was no place to order marmosets and struggled to find sufficient animals to begin my marmoset research lab. None of the National Primate Research Centers had any animals to spare. In November of 2018, I finally managed to acquire four animals, thanks to the generosity of a colleague. However, this small number is not enough to sustain a viable research colony. As an Assistant Professor, the lack of marmosets in the country continues to be a significant challenge to accomplish my research program. Establishing a centralized breeding resource center to disseminate the animals critical to research would meet a pressing need for my own research and the broader marmoset community. Furthermore, as leaders and pioneers in marmoset neuroscience research, Drs Wang and Miller are ideally suited to succeed in this endeavor.

Sincerely

Anirvan Nandy, Ph.D.
Assistant Professor
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Yale University School of Medicine

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Dear Study Section Reviewers,

It is my pleasure to enthusiastically support the U24 proposal by Drs. Xiaoqin Wang and Cory Miller titled ‘Bicoastal Marmoset Breeding and Resource Center’. The marmoset has emerged as a NHP model to revolutionize our understanding of brain functions and human diseases. However, the enthusiasm towards expanding its usage is severely thwarted by the availability of marmosets for research. When I started my lab in 2012, few places were willing to provide adequate and trustworthy supplies of marmosets. I was lucky to eventually receive two animals donated from Dr. Miller’s lab at UCSD and purchased additional four animals from U. of Utah. However, since then, my lab has struggled with marmoset reproduction for almost 3 years in part due to the small size of our colony. Thus, establishing a centralized breeding resource center to disseminate the animals critical to research would meet a pressing need for my own research and the broader marmoset community. More importantly, a centralized breeding colony would have the capacity to monitor and document the marmoset pedigree and to provide critical genetic information for research of a variety of goals. As leaders and pioneers in marmoset neuroscience research, Drs Wang and Miller are ideally suited to succeed in this endeavor.

Sincerely

Yi Zhou, PH.D., Assistant Professor
Director, Laboratory of Auditory Computation and Neurophysiology
College of Health Solutions
Arizona State University

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January 3rd, 2019

Subject: NIH U24 Proposal

Dear Study Section Reviewers

It is my pleasure to enthusiastically support the NIH U24 Proposal entitled 'Bicoastal Breeding and Resource Center' by Drs. Xiaoqin Wang and Cory Miller. Dr. Miller established the first marmoset colony on the west coast at UCSD 9 years ago and we have watched this biomedical model system flourish in the ensuing years, including two colonies that were recently established at the Salk Institute just down the street from our campus. The San Diego area is now emerging as a crucial hub in the rapidly expanding marmoset network and is ideally suited to establish a keystone breeding resource center to serve the broader research community. The University will continue to provide Dr. Miller with the support to expand his existing colony and establish this crucial resource center at UCSD.

Sincerely,

Sandra A Brown
Vice Chancellor for Research
University of California San Diego

JOHNS HOPKINS
UNIVERSITY

Office of the Provost

To Whom It May Concern,

This letter is to certify that Johns Hopkins Research Animal Resources (RAR) stands fully ready to support Dr. Wang's application to expand his marmoset colony and serve as an animal resource to NIH funded researchers at other institutions. Since the inception of the marmoset colony at JHU, RAR has provided clinical, surgical, husbandry, and breeding colony support to Dr. Wang from our team of faculty veterinarians, veterinarians in our laboratory animal medicine training program, certified veterinary technicians, dedicated animal behavior staff, and dedicated husbandry staff. We have extensive experience importing and exporting animals to and from this colony, including cross-country and international shipments. We have previously assisted new facilities in establishing their own marmoset colonies, to include provision of animals, equipment, and extensive consultation on clinical care and husbandry. Our veterinary team has a history of tight, successful collaboration with Dr. Wang, which is reflected in the number and breadth of publications the colony has produced in the realms of neuroscience and veterinary medicine.

Upon receipt of this award, Dr. Wang will have a total of 2,374 square feet of space available for housing marmosets on the East Baltimore (1,728 Sq Ft) and Bayview campuses (644 Sq Ft). Additional space is guaranteed to be made available as necessary to allow for the gradual expansion of the marmoset colony as outlined in this application. This space would come from additional rooms adjacent to Dr. Wang's current colony, on the Bayview campus, and/or in the new vivarium currently under construction on the East Baltimore campus (projected completion in early 2023).

Johns Hopkins University and Research Animal Resources are prepared to provide the space and effort necessary for Dr. Wang to fully execute the aims of this application.

Eric Hutchinson, DVM, DACLAM
Director, Research Animal Resources
Assistant Professor, Molecular and Comparative Pathobiology
Attending Veterinarian, Johns Hopkins University
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SALK INSTITUTE
FOR BIOLOGICAL STUDIES

Kuo-Fen Lee, Ph.D.
Professor
Helen McLoraine Chair in Molecular Neurobiology

Oct. 2, 2019

Dear Xiaoqin and Cory,

I am writing to express my willingness to serve as an unpaid consultant for your NIH application in response to the RFA-MH-20-145 by establishing a Bicoastal Marmoset Breeding Center. My laboratory is actively generating genetically modified marmosets to model neurodegenerative disease with the support of two NIH grants. As marmosets are out-bred animals, we are well versed in the genomic information that is crucial for breeding strategy and pedigree analysis of both wild type and genetically modified marmosets. In addition, I am a co-chair of a national marmoset working group (MWG) comprising veterinarians and scientists that is partly organized and sponsored by NIH OD/ORIP. The MWG has several sub-working group on a wide range of topics, including breeding and genetics of marmosets. Thus I am deeply versed in the latest developments and knowledge on modeling human disease in the marmoset. As the RFA indicates that the breeding colony will eventually breed transgenic marmosets, I would be happy to advise aspects of genetic analysis and breeding of marmosets

Good luck!

Best wishes,

Kuo-Fen

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October 2, 2019

Dear Xiaoqin and Cory,

I am writing to express my support as an unpaid consultant for your NIH application in response to the RFA-MH-20-145 by establishing a Bicoastal Marmoset Breeding Center.

I am pleased to hear that you propose to establish a Bicoastal Marmoset Breeding Center, with two breeding colonies, one on the East Coast at Johns Hopkins University (JHU) and the other on the West Coast at University of California at San Diego (UCSD). I believe that this will be beneficial for all neuroscientists who are using marmosets as the models.

As you know, I have developed the world's first transgenic marmosets in 2009 and immune compromised marmosets by genomic editing technology in 2016. Currently, my research group has generated 15 kinds of genetically modified marmosets. To achieve these goals, we established basements of marmoset artificial reproductive methodologies which include in vitro fertilization, embryonic manipulation, and embryo transfer to surrogate mother. Furthermore, for producing genetically modified marmoset models, we have been maintaining 500-1000 marmoset colony for 10 years. I believe that our experiences and knowledge can help your project.

I will be pleased to work with you in the future to provide our advice and know-how to facilitate the process of developing your own expertise in marmoset reproductive technologies and health care taking. I will be pleased to work with you toward coordinating the development and sharing of new marmoset models.

I am looking forward to seeing the progress of your program and hope that a strong collaboration between our institutions will facilitate the success of the RFA-MH-20-145.

Best regards,

Erika Sasaki, Ph.D.
Department Head,
Department of Marmoset Biology and Medicine
Central Institute for Experimental Animals

Resource Sharing Plan:

The proposed Bicoastal Marmoset Breeding Center will produce large quantities of marmosets for distribution to the broader Neuroscientific community. There are two potential shared resources that will be available from this effort. First, are the animals themselves. We anticipate that by Year 2 of the project, we will be able to sell animals to researchers across the US, with an increased number of animals available in subsequent years. Because of the high demand for marmosets currently, we will distribute animals based on a combination of availability and the needs of individual researchers. Until demand has stabilized, we will commit equal numbers of animals annually to researchers in the following three categories: New Investigators, NIH funded neuroscience projects and large scale molecular neuroscience projects. Researchers within each of these categories can submit requests and will be filled in the order they are received. We will limit the number animals received by any one Investigator to 10 for the first two categories and 20 for the molecular neuroscience projects to ensure that animals are distributed broadly across the community until demand has stabilized. A second resource that will be generated by this project are the genetics of the population. All animals in the Center will be made available for genotyping under the direction of the Marmoset Coordination Center. The outcome of these results may then be utilized to optimize genetic diversity across the US marmoset population.