Dynamic young investigators
Making their mark on a national level

“The (NIH) reviewers felt that the application presented such a strong and well-reasoned effect that it seemed ‘poetic’, and they praised it as ‘one of the best applications’ they had ever reviewed.,” from an NIH/NICHD summary of Dr. Eliza Bliss-Moreau’s recent R21 grant proposal – “Individual differences in early autonomic nervous system activity,” which received a perfect score.

The goal of this research is to investigate variation in infants in one system that is important for emotional life – the autonomic nervous system. The study will quantify spontaneous variation in activity of the two branches of the autonomic nervous system which work together to maintain homeostasis and is highly variable between people, and related to changes in health. Whether variation is stable across the first year of life.

Dr. Bliss-Moreau’s research will utilize a key program at the CNPRC – the Biobehavioral Assessment program – that assesses behavioral phenotypes and biological profiles. She will evaluate whether variation in established behavioral phenotypes (e.g., temperament) and biological markers (e.g., cortisol levels, c-reactive protein levels; serotonin and monoamine oxidase A promoter genotypes) predict ANS activity, and whether variation is stable across the first year of life.

The long-term goal of the research is to establish rhesus monkeys as a good model for affect development across early development so that early biomarkers of, and treatments for, psychopathology can be subsequently identified.

Influence of Social Networks. In another project, Dr. Bliss-Moreau, together with Jessica Vandeleest, PhD (CNPRC postdoctoral investigator), identified. Variations in Emotional Health. One goal of Eliza Bliss-Moreau, PhD, assistant project scientist in the CNPRC Brain, Mind, and Behavior Unit (BMB), is to determine if early indicators that predict long-term affective processing problems can be identified. She posits: “Why is it that some people float through life in a sea of tranquility while others are constantly riding an emotional roller coaster? Why do some emotionally reactive babies grow up to become calm, centered adults and others remain volatile?"

In important progress in ASD research, Dr. Freeman developed a new technique using nonhuman primates by which primate oxytocin receptor binding can be accurately and precisely measured and compared to the vasopressin receptor binding. The technique and oxytocin receptor distribution for rhesus and titi monkeys was published in 2014 (Freeman et al., Neuroscience, July 273-12.23, 2014). (See www.cnprc.ucdavis.edu for more information on Dr. Freeman’s novel technique.)

Utilizing this technique to characterize the distribution of oxytocin receptors in the brain, the research will analyze human brain tissue samples to determine whether there are differences in oxytocin receptor expression and distribution between neurotypical individuals versus those with autism. The project is focused on deepening our understanding of oxytocin brain receptors in humans, with potential for elucidating the neural mechanisms by which oxytocin modulates social cognition, with implications for oxytocin-based pharmacotherapies in psychiatric disorders such as autism and schizophrenia.

Human-macaque conflict zone, Assistant Project Scientist Brianne Reiser, PhD, is a co-investigator on a $1.3M grant through the National Science Foundation, together with PI Dr. Brenda McGowan and co-investigator Dr. Eliza Bliss-Moreau. Also contributing to the project will be Krishna Balasubramaniam, PhD (UC Davis Veterinary Medicine postdoctoral researcher with Dr. McGowan).

The grant was made through the NSF grant program “Dynamics of Coupled Natural and Human Systems”. The focus of this project is understanding how human-macaque conflict unfolds, evaluating three species of macaques in two field sites in India and one in Malaysia in which monkeys and people interact. Macaques have a strong propensity to live alongside humans, and have successfully done so for thousands of years in South and Southeast Asia. The nature of human-macaque interactions varies from raids on agricultural crops to selling food from urban vendors to begging food from tourists at religious temples.

This project will investigate how individual attributes, in combination with the human culture and macaque social dynamics in which these interactions are embedded, determines the real and perceived positive versus negative outcomes of these interactions. The goal is to understand what is driving conflict, so that, ultimately, it can be resolved.

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**From the Director**

A few days ago, I had the chance to visit with the UC Davis Medical Center and catch up with my colleagues there. I was impressed with the progress they have made on their projects and the passion they have for their work. I am excited to see what they will accomplish in the future.

I would like to thank the entire CNPRC team for helping me adjust to my new role. Your dedication and support have been invaluable.

The CNPRC is a unique and important research center. Our non-human primate model is uniquely powerful in its capacity to transform health and disease. Such efforts are ongoing at the CNPRC with an extraordinary group of dedicated team members. However, such efforts require support from the wider community. We are committed to sustaining and developing the highest quality translational research programs where the emphasis is on human health and quality of life.

While UC Davis has made a major commitment to the future of the Primate Center, and in order to fulfill our mission, we are committed to sustaining and developing the highest quality translational research programs where the non-human primate model is uniquely powerful in its capacity to transform health and disease. Such efforts are ongoing at the CNPRC with an extraordinary group of dedicated team members. However, such efforts require support from the wider community. We are committed to sustaining and developing the highest quality translational research programs where the emphasis is on human health and quality of life.

To advance our mission, we need support from the wider community. We are committed to sustaining and developing the highest quality translational research programs where the emphasis is on human health and quality of life. Our team is dedicated to making a difference in the lives of those we serve.

Thank you for your support and for being part of this extraordinary institution. The CNPRC is also part of the University of California, Davis has made a major commitment to the future of the Primate Center, and in order to fulfill our mission, we need support from the wider community. We are committed to sustaining and developing the highest quality translational research programs where the emphasis is on human health and quality of life.

In closing, I would like to thank the entire CNPRC team for helping to make the transition from New York to California a pleasure!
News Around the Center

A relaxing space

A new break area in the administration building is being discovered and used for many purposes—from study partners practicing AAALAS exam questions to a quiet room for relaxation and reading. A huge thank you to Khris Lundy for the vision, persistence, and personal contributions to make this happen, and for her skills in putting the room together at no cost to the CNPRC. Everyone is welcome to come and have it a try!

Behavior Management changes

Dr. Brenda McCowan is resigning from her position as Leader of Behavioral Management Services, but will continue to serve as a Core Scientist in the Brain, Mind and Behavior Unit, and as leader for the Behavioral Research Core. Dr. McCowan has had impressive success at receiving grant funding for multiple, large projects and is devoting her time to directing those grants and developing new opportunities. We would like to thank Dr. McCowan for her outstanding service to the CNPRC and look forward to her continued success and service as a Core Scientist.

Scholarship award

Daniel Dugger, DVM, PhD candidate, received an abstract scholarship award at the American Thoracic Society, Denver, Colorado May 16–20, 2015.

Generous contributions

The 2015 CNPRC SCI research team celebrated the dedication of the Jonas O’Connor Research Facility, acknowledging the invaluable contributions to the success of the research to the O’Connor family, and animal care and research staff at the primate center. (Pictured) Dr. Mark Tuszynski hangs a plaque on one of two trailers that were purchased by the O’Connor family, and staff at the primate center.

Third annual Blood Drive

Thank you to everyone who supported the CNPRC 3rd annual blood drive, July 29, 2015, with their efforts and life-saving donations. The total numbers for the day include: 26 participants, including 10 new donors, who gave 31 pints of blood. Special recognition goes to Paul-Michael Sosa who organized the event with BloodSource, who brought their bloodmobile to the Center and provided friendly and professional services.

‘Bench to Beside’: Television production at the CNPRC

Foundation for Biomedical Research’s “Bench to Bedside”™ is a TV series about inspirational people and animals living with serious illnesses and the cutting-edge biomedical research that could save their lives. Bench to Bedside™ has been nominated for 10 Emmy® Awards and is currently airing in 45 countries. In Fall of 2014, producers were looking for ground-breaking research and compelling human interest stories to showcase, and the CNPRC HIV research program was chosen to be featured in an upcoming episode. Filming took place in February 2015 and the episode will be broadcast in Fall of 2015. This is a great opportunity for the Center to educate the public on the pioneering research being conducted at the CNPRC and to raise awareness about the continued need for medical and scientific research.
Congratulations to Greg Salyards, DVM, MPH, DACLAM

Becomes Diplomat in Laboratory Animal Medicine

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r. Greg Salyards, DVM, MPH, DACLAM, learned on July 14, 2015 that he had successfully passed the American College of Laboratory Animal Medicine qualifying board exam, becoming a Diplomat and board certified in Laboratory Animal Medicine (LAM).

Greg received his Bachelor’s of Science in Animal Science with minors in Biology and Chemistry from the University of Nevada, Reno in 2006 while working in a small animal practice. He took a year off between undergraduate and veterinary school during which time he worked at Charles River Laboratories (Reno, Nevada) where he discovered laboratory animal medicine. He subsequently was admitted to Colorado State University with the ultimate goal of working in LAM and completed his DVM in 2011.

In veterinary school, Greg pursued many extracurricular activities that bolstered his career interests in LAM, including a summer internship at Zo New England Primate Research Center. He completed a one-year internship in LAM with an Emphasis in Infectious Diseases at the University of Georgia and then applied for the CNPRC-UC Davis LAM residency the following year.

Concurrent to his internship and first year of his residency at the CNPRC, Greg also pursued a Master’s of Public Health from the University of Minnesota online, which he completed in 2013.

Greg completed his residency in Laboratory Animal Medicine with a focus in Primate Medicine at UC Davis in November, 2014. He was then hired as a CNPRC staff veterinarian.

His future goals are to further his experiences and opportunities within the field of primate medicine. He currently has two ongoing colony management research projects investigating alternative long-acting formulations of commonly used medications in rhesus macaques with the goal of improving animal health and well-being, while simultaneously increasing savings in time and finances.

Welcome to Dr. Joe Erwin - new resident in Primate Medicine

J
oe Erwin, PhD, Research Professor at George Washington University, is leading Behavior Management Services in CNPRC Primate Services for one year, beginning August 2015. Behavior Management Services is a component of the Primate Well-being Plan that both monitors our animal populations and advises the Enrichment Program for all of the nonhuman primate colonies.

Dr. Erwin earned a PhD in Psychology from UC Davis and has extensive experience in primate management and behavior. He is an independent consultant, has managed socialization and enrichment programs for over two decades and is actively involved in research in the neurobiology of aging in primates. He has worked extensively in academia, zoos, and industry and also conducted field research on wild populations of primates.

The American Society of Primatologists (ASP)

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he American Society of Primatologists (ASP) annual meeting was held in Bend, Oregon, June 17–20, 2015. A large contingent of CNPRC scientists, students and staff participated in the meetings and showed strong leadership, chairing about one quarter of the sessions (Drs. McCowan, Weinstein, Kinally, and Bales), and giving 20 oral and poster presentations.

Numerous researchers from other institutions around the world cited and referenced CNPRC articles and look to CNPRC faculty, staff and post-docs as experts in the field.

Faculty, students and staff from the CNPRC also play important roles in ASP committee work, with most of the committees including members from the CNPRC. Education Committee (and Pre-conference Educational Outreach workshop) – Eliza Bliss-Moreau, Kate Erwin; Faculty Committee – Krishna Balasubramaniam; Education Committee – John Capitanio; Research and Development Committee – Brenda McCowan; and Workshop On Primates Social Networks – Brenda McCowan and Jessica Vandeest.

ASP President’s Forum

Laboratory research with nonhuman primates: conceptual, ethical, and regulatory issues

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he American Society of Primatologists (ASP), founded in 1968, is a professional society for people interested in all aspects of primateology, including questions that are asked in the field, in the lab, and in biomedical research settings. Sometimes there has been tension between people working in these different areas.

Most recently, ASP made a strong public statement in support of lab-based primate researchers that had been targeted by PETA. Because of the controversy surrounding this statement, the ASP President, Dr. Marilyn Norcom, asked Dr. John Capitanio (CNPRC BMB Unit Core Scientist), as a past president of ASP, to convene the first President’s Forum to openly discuss issues pertaining to laboratory research. Dr. Capitanio organized the forum to comprise two one-hour sessions, approximately 24 hours apart.

For the first session, June 18, three presentations were given: Dr. Capitanio spoke about conceptual issues in laboratory research, Dr. Allyson Bennett, of the Harlow Laboratory at University of Wisconsin-Madison spoke on ethical issues, and Justin McNutty, the Senior IACUC Manager at the University of Texas, Austin, spoke on regulatory issues. After the presentations, members of the audience were asked to submit questions anonymously either via an online webpage or through use of a question box at the meeting’s registration table.

The second session, June 19, was a discussion, moderated by Dr. Capitanio, involving panel members and the audience that focused on the questions (about 20) that had been submitted. Use of an anonymous question format was designed to permit undergraduate and graduate students (which comprise the majority of attendees at ASP meetings) the opportunity to freely ask questions. And, because the session was unposed, attendance was very high for both days.

Questions focused on legislative efforts, welfare issues, current topics like the possible value of providing ethologically relevant environments, limitations of captive research, issues surrounding euthanasia, the welfare of humans who work with animals, how IACUCs work (Institutional Animal Use and Care Committees), and the need for more public engagement.

Feedback about the forum was extremely positive, and there was substantial tweeting of the discussion on Twitter. Overall, the consensus was that directly addressing some of these potentially contentious issues in a calm and reasoned manner can help serve the Society’s educational mission and facilitate understanding of issues that many students, in particular, have a limited understanding of.

See page 6 – Out and About – for a complete list of CNPRC presentations.
**Celebrations**

### Bales Selected for UC Davis ADVANCE Scholar Award

Dr. Karen Bales, Brain, Mind, and Behavior Unit Leader, was awarded the 2015 ADVANCE Scholar Award for her research and mentoring at the CNPRC and UC Davis.

The UC Davis ADVANCE program sponsors an award program and lecture series to bring together a multi-disciplinary audience of faculty, students and post-doctoral scholars. Her talk was entitled: “Oxytocin—Social Bonding, Autism, and Women’s Health.”

### Celebrating Team Success

CNPRC staff, students and faculty gathered for a celebration BBQ on February 11, 2015 to acknowledge successful teamwork and everyone’s extraordinary efforts in preparing the Center for the NIH Base Grant site visit in December 2014.

### Translational Highlights

#### Gene therapy treatment developed at the CNPRC shows benefits to brain cells for Alzheimer’s patients

**R**eporting on the first-of-its-kind human clinical trials, researchers designed to test the potential benefits of nerve growth factor gene therapy for Alzheimer’s patients, Mark Tuszyński, MD, PhD, CNPRC affiliate scientist, has found that an experimental gene therapy he developed at the California National Primate Research Center (CNPRC) at UC Davis reduces the rate at which nerve cells in the brains of Alzheimer’s disease patients degenerate and die (Tuszyński, M. H., et al. (2015). Nerve Growth Factor Gene Therapy: Activation of Neuronal Responses in Alzheimer Disease. JAMA Neurology, published online August 24, 2015).

Novel gene therapies, first developed at the CNPRC in the early 2000s, showed great promise in patients with mild Alzheimer’s disease. Further research at the CNPRC with gene transfer therapy using Nerve Growth Factor (NGF) demonstrated in nonhuman primate studies that reversal of damage and restoration of brain function was possible. This program is determining the potential of NGF to prevent or reduce cell degeneration in important cortical regions of the brain.

Targeted injection of the Nerve Growth Factor gene into the patients’ brains rescued dying cells around the injection site, enhancing their growth and inducing them to sprout new fibers. In some cases, these effects persisted for 10 years after the therapy was first delivered.

**Abbie Spinner, CNPRC Clinical Laboratory supervisor, reminisces about the origins of this research:** “I remember processing these cells for Dr. Tuszyński in the late 80’s and early 90’s. It is very exciting to see how efforts from the scientific service labs at the CNPRC helped in such a great discovery.”
**Conferences and Symposia**

**Publications, cont’d**


Out & About

Dr. Dennis Hartigan-O’Connor, gave a talk entitled: “Early infant diet has long-term effects on the immune system through modulation of the gut microbiota in rhesus macaques” at the Translational Science Meeting, Washington, DC, April 17, 2015.

At the American Society for Microbiology 115th Annual Meeting in New Orleans, Louisiana, May 31, 2015, Nicole Narayan gave a Young Investigator oral presentation entitled: “Early infant diet has long-term effects on the immune system via modulation of the gut microbiota.”

Nicole Narayan also presented a poster entitled: "Gut microbiota drives toll-like receptor (TLR) signaling in the intestine" at the Kenneth Rainin Foundation Innovation Symposium: Wound healing, repair, and IBD, July 22, 2015.

Dr. Alice Tarantal hosted the NHLBI 35th Annual Gene Therapy Symposium for Heart, Lung, and Blood Diseases, November 19-21, 2014, in Somerset, California. The 2014 focus topic was “Germicidal Editing.”

Dr. Tarantal was an invited speaker at the American Society of Cell and Gene Therapy (ASCGT) 18th Annual Meeting, May 13-16, 2015, New Orleans, Louisiana, at the Scientific Symposium: Clinical Applications of Stem Cells and Engineered Tissues. Her presentation was entitled: “IND-enabling studies: cell-based tissue engineering.” Dr. Tarantal was also an invited participant at the ASCGT Mentoring Event and a member of the Stem Cell Committee.

Dr. Tarantal was an invited participant at the NIH Office of Science Policy and Strategic Planning Conference, Panel 3, July 9, 2015, in Washington, DC.

Representing the Respiratory Diseases Unit: Dr. Lisa Miller presented a talk at the Society for Toxicology, in San Diego, California, March 22–26, 2015, entitled “Persistent immune and pulmonary effects of wildfire smoke during infancy: findings from a nonhuman primate cohort.”

At the American Thoracic Society, in Denver, Colorado May 16–20, 2015:
Dr. Miller chaired a Mini-Symposium entitled “Remodeling of the bronchovascular unit and lung disease”.
Dr. Kent Pinkerton chaired a Symposium “One health: how humans, animals and the environment interact to increase risk of antibiotic resistance”.

Monica Jimenez, Junior Specialist through a PSI Diversity Supplement, presented a talk entitled: “Impact of Helicobacter pylori infection on the infant lung: airborne microbe and immunomodulation of airway epithelium.”

Daniel Dugger, DVM, PhD candidate, presented a poster entitled: “IL-22R1 expression is developmentally regulated in nonhuman primate airway epithelium and responds to the histone deacetylase inhibitor trichostatin A.”
The CNPRC has been awarded $33.2 million over three years from the National Institutes of Health. The continuation of the base grant from the NIH Office of Research Infrastructure Programs provides essential support for the CNPRC—an international leader in biomedical research with nonhuman primates. Funding from the NIH supports the infrastructure and basic functions of the Center, including core research facilities and scientists, animal care, and administrative functions.

"This award from NIH represents a huge vote of confidence in the CNPRC faculty and staff, who conduct research that is critical to human health while managing a large colony of nonhuman primates in an exemplary and humane manner" said Harris Levin, vice chancellor for research.

Grants Awarded
July 2014 – September 2015
Karen Baker, PhD, and Sara Frenom, PhD, received a 2-year grant from National Institutes of Health to study Molecular characterization of enteropathy disease.
Melissa Bevoort, PhD, received a grant from Genentech to study effects of age on bone health.
Catherine van Dijk, MD, received a 3-year grant from National Institutes of Health to study 'Replacement thymic epithelial cells are required to maintain thymic function'.
John Capitanio, PhD, received a 4-year grant from the National Institutes of Health to study 'Asthma, anxiety and GR abnormalities in non-human primates'.

Infectious Diseases Unit
Study Leads to Meningococcal Vaccine Improvements
O n February 12, 2015, CNPRC Affiliate Scientists Drs. Koen Van Rooym, Peter Beerman, and Dan Granoff announced important findings from a pilot project study conducted at the CNPRC on improving the effectiveness of the meningococcal vaccine for prevention of sepsis and meningitis caused by meningococcal serogroup B (Meningococcus B). This is the first time that deadly bacterial infection which accounts for one-third of the meningococcal meningitis cases in the U.S. (“The rhesus macaque immunogenicity model to investigate the effect of binding component F of meningococcus B protein binding component F to a vaccine antigen known as Factor B binding protein (FBBp). This antigen is a component of both serogroup B vaccines licensed in the U.S., including Bexsero®. The research team recently discovered that a subset of rhesus macaques have complement Factor H that binds one of the most important antigens (Factor H binding protein, FBBp) in the serogroup B vaccine, and that binding of FH from these animals is similar to human FH.

The study has provided valuable information for development of improved FBBp vaccines for humans and highlights the value of the nonhuman primate model in HIV/AIDS vaccine immunology and immunogen discovery (CHAVI-ID)”.

These studies, although preliminary, provide an important avenue of research to pursue. One might envision developing vaccines that induce an immunological tolerance (tolerogenic) response in people at risk for HIV infection. Similar vaccines might be useful against other chronic infectious agents where, as with HIV, pathology and spread of the pathogen are often associated with an exaggerated autoimmune response. These studies also highlight the fetal proof-of-concept model developed by Dr. Tarran to address preclinical questions such as the safety of new methods of cell and gene transfer and novel vaccines prior to Phase I clinical trials.

Research Highlights

Reproductive Sciences and Regenerative Medicine

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The primary objective of the National Heart, Lung, and Blood Institute (NHLBI) Annual Gene Therapy Symposium is to provide a novel and informal scientific setting for the exchange of innovative research findings by focusing on the inclusion of investigators and trainees across the nation that do not typically interact at other meetings. The opportunities for cross-fertilization of ideas between investigators and trainees in divergent, yet relevant, fields remains a major challenge because of the sheer size of many national and international meetings.

The Annual Gene Therapy Symposium was designed to bring together a unique multidisciplinary group of participants to address unpublished works-in-progress, cutting edge technologies, and key issues of national interest on regenerative medicine and gene therapy (www.GTS.uc Davis.edu).

The focus topic of the 13th Annual Gene Therapy Symposium for Heart, Lung, and Blood Diseases was “Genomic Editing,” an exciting area of current research and therapeutic promise. An outstanding group of speakers presented new information to advance creative thinking and new collaborations. The keynote speaker was Dr. Matthew Porteus, Stanford University (“Genomic Editing: The Time is Ripe for Translation”), followed by intriguing presentations on viral and nonviral vectors, sessions that addressed key areas of preclinical and clinical research for diseases such as sickle cell disease, HIV/AIDS, and muscular dystrophy. Special editing techniques by Dr. J. Keith Joung, Harvard Medical School; and a mini-workshop on “Cell Engineering and Immunotherapy” presented by Dr. Andrew Scharenberg, University of Washington.

The 13th Annual Gene Therapy Symposium provided an opportunity for translational research with renowned investigators in an informal setting where they could discuss their research, and forge new collaborations. The Annual Gene Therapy Symposium provides a highly engaging and interactive environment for trainees and investigators to advance innovative treatments for human disease across the lifespan.

Respiratory Diseases

Women, Lung Health, and Climate Change

There is growing evidence that a number of pulmonary diseases exhibit sex-based differences, and with a greater degree of severity, than men.

Kent Pinkerton, PhD, Core Scientist in the CNPRC Respiratory Diseases Unit and the CNPRC Inhalation Exposure Core at UC Davis (where he directs the UC Davis Office of Research. The 14th annual Gene Therapy Symposium for Heart, Lung, and Blood Diseases will be held November 18 – 20, 2015. The focus topic is Genetic Disease Applications. Special

The development and progression of certain common respiratory diseases has been found to differ by sex. One such disease is COPD, now the third leading cause of death in the US. Traditionally more prevalent in men, women now account for over 50% of COPD deaths in the US. The increase prevalence of COPD in women was thought to be due to changing smoking patterns and women taking on more traditional male occupations. However, growing evidence supports significant sex-based differences in the disease. For example, of never-smokers that develop COPD, women 1.5 times more likely to be diagnosed than men.

In the context of respiratory diseases, one global environmental exposure that has particular relevance for women is household air pollution (HAP) that results from indoor burning of solid fuels (biomass and coal) for cooking and heating. HAP exposure is associated with approximately 1 million deaths each year, predominantly from COPD, cardiovascular diseases, acute pneumonia in children under 5 and lung cancer. The vast majority of HAP related deaths and disabilities occur in low- and middle-income countries among those households living in severe poverty, and women and children have the highest exposure to HAP due to their non-employment and domestic roles.

Households typically have limited access to fuels, so wood, charcoal, animal dung, coal or crop residues are used for cooking using either open fires or traditional unvented stoves. These cooking fires have low combustion efficiencies (e.g., they result in excess emissions, such as black carbon or “soot,” into the households, blackening the interior walls. The daily breathing of air that exceeds WHO air quality standards by 10 to 100 fold has obvious health risks. Women often have the domestic responsibility for cooking and for childcare, and thus are, along with children, particularly exposed to very unhealthy air to breathe.

The good news is that cleaner cooking solutions, such as highly efficient cookstoves or effective ventilation of stoves by well-maintained chimneys, can significantly reduce household exposures and improve the health of children worked. There is also an increasing global awareness of the challenge ahead and the need to improve and implement cleaner cooking solutions that are acceptable by households and communities in the very different social and cultural settings around the world. The scale of the problem is daunting, with a need to reach hundreds of millions of households to find the best solutions and the best mechanisms to implement such strategies.

With the CNPRC’s extensive capabilities and resources, and a myriad of research projects under way, Dr. Pinkerton is well positioned to understand the mechanisms underpinning respiratory disease and to develop new strategies to alleviate the detrimental health outcomes of pollutant exposures.

Different mechanisms underlying disease susceptibility in females and males may be uncovered more readily as future research addresses sex-based disparities in symptoms and diseases of the respiratory system.

J. Michael McCune, MD, PhD (UCSF) published a study that supports the possibility that a variety of conditions may offer a new avenue to resistance against HIV. Traditionally, vaccines are designed to induce an immune response that can specifically recognize and destroy a given target, for example, an infectious agent. Although highly successful against many acute infectious agents such as measles, this approach has not only failed to protect against HIV, but also, in some cases, has been associated with more infections, not less. Because traditional vaccines generally induce activation of the immune system, they may paradoxically favor replication and spread of HIV. If this is the case, then protection against HIV may best be achieved by an immune response that is different from those normally induced by traditional vaccines.

An alternative vaccination approach that was addressed in these studies is to prevent the replication and spread of HIV in vivo by creating a vaccine that suppresses a hyperreactive response against the virus, for example, one that generates tolerance to the virus in an antigen-specific manner. If such a response were to dampen the rate of viral spread, then the virus might be cleared by the normal processes of cell death and removal. Building on the knowledge that fetal exposure to infectious pathogens in utero can result in reduced antibody responses, or

Continued on next page
How estrogen affects higher cognitive functions and synaptic health, with studies in nonhuman primates, mice, and humans.

Male monkeys were administered hormone replacement therapy (estrogen with or without progesterone) at the beginning of, or during, menopause, would protect against cognitive failure, a condition normally taken with increasing age.

Although it is not certain whether estrogen therapies do not protect cognitive functions and may even cause harm when administered to women over the age of 65 years, it is possible that the modifications characterizing brain aging, such as a reduction in brain volume and in neuronal size, alterations in neurotransmitter systems, and a decrease in the number of dendritic spines, form an adverse background that prevents the neuroprotective effects of exogenous estrogen on the brain. Other factors that have probably contributed to the inconsistencies of the estrogen-cognition literature include differences in the estrogen form utilized, route of administration, cyclic versus continuous regimens, whether progesterone was administered concomitantly, and failure to account for age-related alterations in hormones other than estrogen.

To understand the variables and determine the safest and most effective treatment for aging women, Dr. Morrison turns to his work with the rhesus monkeys at the CNPRC. Nonhuman primate models have been used thus far for women have concentrated largely on circulating estrogen and progesterone levels rather than on receptor dynamics, synaptic regulation and downstream effect of changes that result from changes in circulating estrogen. The focus of new studies aimed to include these possible variables if we are to develop more successful treatments. It is possible that the indirect effects of estrogen in terms of other hormonal changes may provide a deeper understanding of the relationship between aging and synaptic health.

In summary, the researchers note a need for "more detailed appreciation of the signaling cascades activated by estrogen, the distinct role of classical and nonclassical actions for each receptor, and age- and menopause-related alterations of such processes which will be required to develop interventions for menopausal women that are both more effective and more tailored to individual variations."
Researchers highlight the new understanding of how estrogen affects cognitive functioning and synaptic health. They discuss the good, the bad, and the ugly: estrogen. Estrogen, such as a familiar hormone, and such a large influence on everyone’s health, young and old. With an abundance of estrogen during women’s reproductive years, it is an invaluable component in reproductive, bone, and neurological health. However, aging and the associated decrease of estrogen throughout the body, women cope with hot flashes, cognitive decline, digestive problems, and bone fragility. For aging men, unbalanced estrogen levels increase the risk of stroke, coronary artery disease, and prostate enlargement or prostate cancer.

Estrogen, aging, and synaptic health. Significantly expanding our understanding of how estrogen affects neural health during aging, Dr. John Morrison, CNPRC Director, focuses his research on the effects that estrogen has on the health and protection of neuronal synapses in the brain, the impact of prolonged male-level estrogen states on learning and memory processes, and new therapeutic strategies to facilitate successful aging (e.g., having a low probability of disease), high cognitive and physical abilities, and active engagement in life. Taking into account that changes in the aging nervous system are subtle, he is hopeful that they can be reversed and cognitive performance may be improved by pharmacological treatments.

Longer female life expectancy has meant that women now live a third of their lives beyond the end of their ovarian function, with 33,000 Americans undergoing menopause each month. Many women will have decades of healthy living after menopause, highlighting the importance of this research in understanding the increased vulnerability of aging women to cognitive decline and potentially, a greater susceptibility to neurodegenerative diseases, such as Alzheimer’s disease.

Throughout a woman’s lifetime, estrogen facilitates cognitive function through its effects on synapse structure and function. With aging, estrogen levels fluctuate within an extended family, producing non-specific changes in circulating estrogen. Cognitive decline during aging is observed in memory abilities (e.g., verbal memory, visual perception and verbal fluency), focusing attention efficiently, and speed of information processing.


At the CNPRC, a large colony of aged rhesus macaques live well past their normal lifespan, reaching their mid-30s (wild rhesus monkeys generally live to around 19 years of age). Excellent health care and nutrition, and aging in place with their extended families, results in good health and longevity, providing researchers with opportunities to understand the aging process in primates. The aged colony at the CNPRC is supported by the National Institutes of Aging, NIH.

Numerous long-term studies have confirmed that the distribution patterns of estrogen receptors and production in rhesus monkeys are similar to what is observed in humans, mimicking natural estrogen cycles. Studies in nonhuman primates also show that, similar to humans, both age and menopause are related to cognitive decline, which is highly relevant for developing interventions for post-menopausal women.

In addition to changes affecting cognitive decline, it is possible that the change in neuronal functioning from low estrogen levels renders neurons more vulnerable to degradation in neurodegenerative diseases such as Alzheimer’s disease (AD). Research over the past decade has led to a growing appreciation that the role that estrogen plays relevant to the influence of factors on the nutrition of tissues and protection of neurons during adulthood.

There is considerable evidence suggesting that the use of estrogen therapies during the menopause and postmenopausal periods may decrease the risk of AD and other neurologic disorders, though the clinical data are inconsistent and this remains controversial. In addition, other hormones are altered with age and menopause as well (e.g., adrenal steroids) and these changes may contribute to functional decline as well. Nevertheless, estrogenic effects on neurons require that we take into account the most recent data on hormone neurobiology, in order to administer the hormone at the right time, with the right formulation and to the appropriate population of women.

Estrogen therapies to nurture and protect aging neurons.

The attempt to delay or prevent the cognitive impairment occurring with aging is a major scientific priority to protect the quality of life for women during the latter third of their lifespan. During the past two decades, researchers have tried to verify if the administration of estrogen to women at the beginning of, or during, menopause would protect against the significant decrement normally taken place with increasing age.

Although it is not certain why estrogen therapies do not protect cognitive functions and may even cause harm when administered to women at the age of 65 years, it is possible that the modifications characterizing brain aging, such as a reduction in brain volume and in neuronal size, alterations in neurotransmitter systems, and a decrease in the number of dendritic spines, form an adverse background that prevents the neuroprotective effects of exogenous estrogen on the brain. Other factors that have probably contributed to the inconsistencies of the estrogen-cognition literature include differences in the estrogen form utilized, route of administration, cyclic versus continuous regimens, whether progestins were administered concomitantly, and failure to account for age-related alterations in hormones other than estrogen.

To understand the variables and determine the safest and most effective treatment for aging women, Dr. Morrison turns to his work with the rhesus monkeys at the CNPRC. Nonhuman primate models have been shown to closely recapitulate clinically relevant hormone treatments in humans, demonstrating the efficacy, safety and unique side effects of estrogen replacement therapies. Using a cohort of young and aged ovariectomized female monkeys, the effects of estrogen were experimentally tested on pyramidal neurons (neurons found in the cerebral cortex, the hippocampus, and the amygdala, and the primary excitatory neurons in the mammalian brain).

In promising results, Dr. Morrison showed that in aged ovariectomized female monkeys, a cyclic estrogen hormone replacement therapy that closely mimics the natural fluctuations of estrogen in premenopausal monkeys, reverses age-related impairments in working memory, retaining cognitive function. Estrogen replacement also improved executive functions in middle-aged ovariectomized monkeys.

Nonhuman primate models mimicking clinically relevant hormone treatments.

In contrast to the cyclic estrogen regimen that produced procognitive effects in rhesus monkeys, the hormone replacement therapy used in women's Health Initiative Memory Study trial consisted of estrogenic compounds combined with a progestin, in a daily regimen. Therefore, hormone treatments modeled after those used in clinical settings were tested in aged ovariectomized monkeys.

Studies in nonhuman primates show that, similar to humans, both age and menopause are related to cognitive decline, which is highly relevant for developing interventions for post-menopausal women.

Treatments that included daily estrogen, cyclic estrogen with cyclic progesterone, or cyclic estrogen with cyclic progesterone, all failed to improve relevant working memory in aged ovariectomized monkeys. Young ovariectomized monkeys also showed parallel results; continuous estrogen with or without progesterone resulted in neuronal spine density and morphology that were indistinguishable from those receiving a control vehicle alone.

Together, these studies suggest that the specific formulation of hormones (estrogen alone versus a combination of estrogen and progesterone) and the treatment schedule (daily versus cyclic) are both key factors for estrogen to exert its positive effects on cognitive and synaptic health. These studies provide evidence that the standard forms of hormone replacement therapy commonly prescribed to women may not provide the same cognitive and synaptic benefits as formulations that mimic the natural menopausal cycle.

Further research for improved health. Among the many functions estrogen has on the brain, estrogen also improves cerebral metabolic rate and blood flow, and exerts many anxiolytic effects. The antidepressant effects of estrogen are noteworthy in light of strong evidence that mitochondrial dysfunction and damage accrued from oxidative stress precede, and may be causative for, neurodegenerative disorders such as Alzheimer’s disease.

While it seems clear that a decline in circulating estrogen can affect brain regions and the cognitive processes they mediate, such effects are highly variable in women and we do not know the source of such variability. The hormone treatments that have been used thus far for women have concentrated largely on circulating estrogens at contraceptive levels rather than on receptor dynamics, synaptic regulation and downstream effect of changes that result from changes in circulating estrogen. The focus of new studies has tended to include these possible variables if we are to develop more successful treatments. It is possible that the indirect effects of estrogens in terms of other hormonal changes may provide a deeper understanding of the relationship between aging and synaptic health.

In summary, the researchers note a need for a "more detailed appreciation of the signaling cascades activated by estrogen, the distinct role of classical and nonclassical actions for each receptor, and age- and menopause-related alterations of such processes which will be required to develop interventions for menopausal women that are both more effective and more easily tailored to individual variations".
The development and progression of certain common respiratory diseases has been found to differ by sex. One such disease is COPD, now the third leading cause of death in the US. Traditionally more prevalent in men, women now account for over 50% of COPD deaths in the US. The increased prevalence of COPD in women was thought to be due to changing smoking patterns and women taking on more traditional male occupations. However, growing evidence supports significant sex-based differences in the disease. For example, of never-smokers that develop COPD, women 1.5 times more likely to be diagnosed than men.

In the context of respiratory diseases, one global environmental exposure that has particular relevance for women is household air pollution (HAP) that results from indoor burning of solid fuels (biomass and coal) for cooking and heating. HAP exposure is associated with approximately 1.6 million deaths each year, predominantly from COPD, cardiovascular diseases, acute pneumonia in children under age 5 and lung cancer. The vast majority of HAP related deaths and disabilities occur in low- and middle-income countries among those households living in severe poverty, and women and children have the highest exposure to HAP due to their domestic roles.

Households typically have limited access to fuels, so wood, charcoal, animal dung, coal or crop residues are used for cooking using either open fires or traditional unvented stoves. These cooking fires have low combustion efficiencies, results in excess emissions, such as black carbon or “soot,” into the households, blackening the interior walls. The daily breathing of air that exceeds WHO quality standards has been linked to women’s health risks. Women often have the domestic responsibility for cooking and for childcare, and thus are, along with children, particularly exposed to unhealthy air to breathe.

The good news is that cleaner cooking solutions, such as highly efficient cookstoves or effective ventilation of stoves by well-maintained chimney, can significantly reduce household exposures and improve health of children worldwide. There is also an increasing global awareness of the challenge ahead and the need to improve and implement cleaner cooking solutions that are acceptable to households and communities in the very different social and cultural settings around the world. The scale of the problem is daunting, with a need to reach hundreds of millions of households and find the best solutions and the best mechanisms to implement such strategies.

With the CNPRC’s extensive capabilities and resources, and a myriad of research projects under way, Dr. Pinkerton is well positioned to understand the mechanisms underlying respiratory disease and to develop new strategies to alleviate the detrimental health outcomes of pollutant exposures.

Different mechanisms underlying disease susceptibility in females and males may be uncovered more readily as future research addresses sex-based disparities in symptoms and diseases of the respiratory system.
Infectious Diseases Unit Study Leads to Meningococcal Vaccine Improvements

O n February 12, 2015, CNPRC Affiliate Scientists Drs. Koen Van Rompay, Peter Beernink, and Dan Granoff announced important findings from a pilot project study conducted at the CNPRC on improving the effectiveness of the meningococcal vaccine for prevention of septis and meningitis caused by Men B. This study showed that, during and sometimes deadly, bacterial infection which accounts for one-third of the meningococcal meningitis cases in the U.S. ("A rhesus macaque immunogenicity model to investigate the effect of binding complement factor H on meningococcal factor H binding protein vaccines." Granoff DM, et al, Journal of Infectious Diseases Sep 12, 2015). This life-threatening bacterial infection of the blood, brain, and spinal cord is spread from person-to-person, and the bacteria can be transmitted from a person who appears healthy. First-year college students are especially vulnerable to contracting meningococcal disease by living and studying in close quarters, vaccines are recommended for entering students. Meningococcal disease in non-human primates (Macaque or Meroce) offer protection against 4 groups of meningococcal bacteria, but do not cover serogroup B. In November 2014 and January 2015, the FDA approved two new Meningitis B vaccines (Trumeno and Bexsero,) that will be available to prevent infection with the more common serotype B strain causing meningitis, and represent a significant step forward in protecting against this devastating disease.

The study has provided valuable information for development of improved FHB vaccines for humans and highlights the value of the non-human primate models in improving safety and immunogenicity against meningococcal disease. These studies, although preliminary, provide an important avenue of research to pursue. One might envision developing vaccines that induce an immunological tolerance (tolerogenic) response in people at risk for HIV infection. Such vaccines might be useful against other chronic infectious agents where, as with HIV, pathology and spread of the pathogen are often associated with an activated inflammatory response. These studies also highlight the fetal proof-of-concept model developed by Dr. Tarantal to address preclinical questions such as the safety and tolerability of these vaccines. In 2013 and 2014, there were outbreaks of this work in improving safety and immunogenicity against meningococcal disease.
At the 2015 American Society of Primatologists meeting held in Bend, Oregon, Dr. Bliss-Moreau, et al., also presented two posters: “Framing the autistic spectrum: increased pro-inflammatory cytokines and virulence factors in the development of somatic and reproductive dysfunction in rhesus macaques” (Macaca mulatta) and “Animal models of early event-related predict affective behavior.”

Conferences and Symposia

Representing the Brain, Mind, and Behavior Unit:


Also presenting posters at the Society for Affective Science meetings were: Gilda Moadab (entitled: “Are there social dimensions to emotion? Using novel social conditions to investigate the role of the amygdala in social and affective life.”) and Dr. Jin Zhang (“Affective salience in the macaque network in the anterior insula.”)

Dr. Mari Golub attended the joint meeting of the Developmental Neurobiolgy Society and the International Neurotoxocology Association in Montreal, Canada, June 27-July 1, 2015. She presented two posters: “Forebrain with the antidepressant fluoxetine increases peer social interaction in juvenile rhesus monkeys” and “Is there a social dimension to emotion? Using novel social conditions to investigate the role of the amygdala in social and affective life.”

Dr. Beirne Brianis gave an oral presentation entitled: “Interdisciplinary symposium on primate social and biological networks – network dynamics of social stability” at the 84th Annual Meeting of the American Association of Physical Anthropologists, March 25–28, 2015, in St. Louis, Missouri; and at the Statistical Sciences Symposium, Network Data: Information and Sciences, Department of Statistics, University of California, Davis, California, on March 31, 2015, entitled: “Characterizing social stability from social networks.”

Dr. Brenda McCowan spoke at the Institute of Social Science, University of California, Davis, May 8, 2015. Her talk was entitled: “Connection matters: group cohesion and collapse in rhesus macaque societies.”

Dr. Jessica VanDeelen gave an oral presentation entitled: “Social-status interacts with social anxiety to influence pro-inflammatory cytokine levels and viral antibody levels in rhesus monkeys” at the American Psychosomatic Society 73rd Annual Meeting held in Savannah, Georgia, March 18–21, 2015.

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The American Society of Primatologists (ASP) annual meeting was held in Bend, Oregon, June 17–20, 2015. A large contingent of CNPRC scientists, students and staff participated in the meetings and showed strong leadership, chairing about one quarter of the sessions (Dr. McCowan, Weinstein, Kinmailly, and Bales), and giving oral and poster presentations. Numerous researchers from other institutions around the world cited and referenced CNPRC articles and look to CNPRC faculty, staff and post-docs as experts in the field.

Faculty, students and staff from the CNPRC also play important roles in ASP committee work, with most of the committees including members from the CNPRC. Education Committee (and Pre-conference Educational Outreach workshops) – Eliza Bliss-Moreau, Katie Leaverton, and Krishna Balasubramaniam; Education and Development Committee – Karen Bales; Publications Committee – John Capitanio; Research and Development Committee – Brenda McCowan; and Workshop On Primates Social Networks – Krishna Balasubramaniam, Brinnie Beisner, Jian Jin, Brenda McCowan and Jessica VandeLeest.

Welcome to Dr. Joe Erwin
Leading Behavior Management Services

J oe Erwin, PhD, Research Professor at George Washington University, is leading Behavior Management Services in CNPRC Primate Services for one year, beginning August 2015. Behavior Management Services is a component of the Primate Well-being Plan that both monitors our animal populations and advises the Enrichment Program for all of the nonhuman primate colonies.

Dr. Erwin earned a PhD in Psychology from UC Davis and has extensive experience in primate management and behavior. He is an independent consultant, has managed socialization and enrichment programs for over two decades and is actively involved in research in the neurobiology of aging in primates. He has worked extensively in academia, zoos, and industry and also conducted field research on wild populations of primates.

Dr. Eliza Bliss-Moreau introduces her talk at ASP: “A rhesus macaque, a tufted griffon, and a golden retriever walk into a bar…” She is investigating how a group’s social dynamics may affect health and mental health outcomes.

I love Beisner’s presentation style. She makes complex ideas simple to understand.

Dr. Brinnie Beisner, BMB, gave an oral presentation discussing her valuable observational data from many years at the CNPRC to understand what is contributing to stability and instability, and how to improve group dynamics for nonhuman primates.

Her talk was tweeted and retweeted before she was even finished, praising her clarity and ability to take a complex subject and make it accessible to the audience.

See page 6 – Out and About – for a complete list of CNPRC presentations.
Investigator Highlights

Dynamic young investigators Making their mark on a national level

"The (NIH) reviewers felt that the application presented such a strong and well-reasoned effect that it seemed "poetic," and they agreed that it was "one of the best applications they had ever reviewed." - from an NIH/NCRRD summary of Dr. Eliza Bliss-Moroney's recent R21 grant proposal – "Individual differences in early autonomic nervous system activity." - which received a perfect score.

Variations in Emotional Health. One goal of Eliza Bliss-Moroney, PhD, assistant project scientist in the CNPRC Brain, Mind, and Behavior Unit (BMB), is to determine if early indicators that predict long-term affective processing problems can be identified. She asks "Why is it that some people float through life in a sea of tranquility while others are constantly riding an emotional roller coaster? Why do some emotionally reactive babies grow up to become calm, centered adults and others remain volatile?"

The goal of this research is to investigate variation in infants in one system that is important for emotional life – the autonomic nervous system. The study will quantify spontaneous variation in activity of the two branches of the autonomic nervous system which work together to maintain homeostasis and is highly variable between people, and related to variation in both healthy and pathological affective experience. Variation appears to manifest at least by early childhood but what we do not know is how much variation exists in ANS functioning during infancy, whether early ANS variation relates to other behavioral or biological phenotypes, how stable variation is across development, and what predicts its stability.

Dr. Bliss-Moroney’s research will utilize a key program at the CNPRC – the BioBehavioral Assessment program – that assesses behavioral phenotypes and biological profiles. She will evaluate whether variation in established behavioral phenotypes (e.g., temperament) and biological markers (e.g., cortisol levels, heart rate variability, and monoamine oxidase A promoter genotypes) predict ANS activity, and whether variation is stable across the first year of life.

The long-term goal of the research is to establish rhesus monkeys as a good model for affect development across early development so that early biomarkers of, and treatments for, psychopathology can be subsequently identified.

Influence of Social Networks. In another project, Dr. Bliss-Moroney, together with Jessica Vandeleest, PhD (CNPRC postdoctoral investigator), Brenda McCowan, PhD (BMB Core Scientist), and Sathyi Dandekar, PhD (BMB Director), was awarded a 5-year grant from the National Institute of General Medical Sciences entitled "Determining the dynamic influence of social networks on development and health trajectories." The project will investigate how infant development unfolds in the context of social networks, by following rhesus monkey mothers and their infants to track maternal and infant development and health traits. The project will investigate how infant development unfolds in the context of social networks, by following rhesus monkey mothers and their infants to track maternal and infant development and health traits.

Existing research of the CNPRC and other institutions has demonstrated that our human social environments strongly impact our health. How can this relationship be established and how infant development shapes the impact of social environment on health is unknown. This CNPRC study will evaluate multiple facets of infant development as they relate to each other and to the development of social networks and health outcomes, allowing us to determine what aspects of social environment cause changes in health.

Oxytocin and Autism. Sara Freeman, PhD (postdoctoral researcher in BMB) with project PI Dr. Karen Bales (BMB Unit Leader) will be collaborating on a National Institute of Mental Health R21 grant entitled: "Characterization of oxytocin receptors in autism spectrum disorder".

Oxytocin (OT) is a hormone produced in the brain that modulates a variety of complex social behaviors. As a result, the OT system has been highly implicated in the biology and treatment of autism spectrum disorder (ASD), a common and impairing condition that is characterized in part by deficits in sociality.

In important progress in ASD research, Dr. Freeman developed a new technique using nonhuman primates by which primate oxytocin receptor binding can be evaluated. This new technique is likely to be more reliable than the current methods of assessing oxytocin receptor expression and distribution between neurotypical individuals and those with autism. The project is focused on understanding our understanding of oxytocin brain receptors in humans, with potential for elucidating the neural mechanisms by which oxytocin modulates social cognition, with implications for oxytocin-based pharmacotherapies in psychiatric disorders such as autism and schizophrenia.

Human-macaque conflict zone. Assistant Project Scientist Briinne Bieder, PhD, is a co-investigator on a $1.13M grant through the National Science Foundation, together with PI Dr. Brenda McCowan and co-investigator Dr. Eliza Bliss-Moroney. Also contributing to the project will be Krishna Balasubramaniam, PhD (UC Davis Veterinary Medicine postdoctoral researcher with Dr. McCowan).

The grant was made through the NSF grant program "Dynamics of Coupled Natural and Human Systems". The focus of this project is understanding how human-macaque conflict unfold, evaluating three species of macaques in two field sites in India and one in Malaysia in which monkeys and people interact. Macaques have a strong propensity to live alongside humans, and have successfully done so for thousands of years in South and Southeast Asia. The nature of human-macaque interactions varies from raiding agricultural crops to stealing food from urban vendors to begging for food from tourists at religious temples.

This project will investigate how individual attributes, in combination with the human culture and macaque social dynamics in which these interactions are embedded, determines the real and perceived positive versus negative outcomes of these interactions. The goal is to understand what is driving conflict, so that, ultimately, it can be resolved.

The Center has tremendous potential to deliver profound discoveries in human and animal health given its current strengths, the commitment to its success from UC Davis, and the fact that it is embedded in a university with extraordinary breadth and depth in basic and applied biology," Morrison said. "I look forward to working with my new colleagues to build the CNPRC into the translational powerhouse that we all envision.

Julie Freischlag, vice chancellor for Human Health Sciences and dean of the School of Medicine, said: "We are thrilled to have John Morrison join the UC Davis team and we regard this recruitment as an excellent collaborative effort involving multiple schools, the Office of Research and the provost's office."

Michael Lairmore, dean of the School of Veterinary Medicine, added: "We are excited about the recruitment of Dr. Morrison, a world-class researcher and experienced administrator. He will bring a wealth of experience in research and leadership that will enhance the outstanding scientific foundation of biomedical research established at the CNPRC as it helps build the future of basic and translational medicine at UC Davis and beyond."