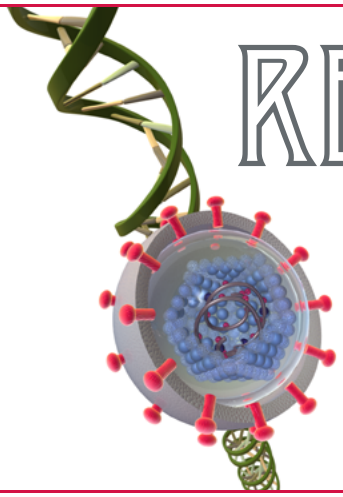


RETRO-ACTIVE NEWS

Newsletter of the Center for Retrovirus Research
at The Ohio State University

2022 Highlights

Nicholas Funderburg and Namal Liyanage receive NIH U01 to explore the consequences of lifelong HIV and antiretroviral therapy (ART) on the immune systems of perinatally infected adolescents

Dr. Nicholas Funderburg, Associate Professor, Division of Medical Laboratory Science, School of Health and Rehabilitation Sciences and **Dr. Namal Liyanage**, Assistant Professor, Microbial Infection/Immunity and Veterinary Biosciences received a five year, $3.8M U01 from the National Institute for Allergy and Infectious Diseases (NIAID) titled "The role of trained immunity and mitochondrial dysfunction on innate immunity in children and adolescents aging with PHIV (TIMING-PHIV)."

Perinatally acquired HIV (PHIV) infection and lifelong antiretroviral therapy (ART) likely alter the development and function of the immune system. Chronic immune activation is associated with HIV infection in adults and is related to all-cause mortality in this population. Adolescents with PHIV will likely experience immune activation for their entire lives and this persistent inflammation may exacerbate comorbidities (e.g., cardiovascular disease, metabolic syndrome and frailty) in this population as they age. This persistent inflammation may be driven by trained immunity, a process by which cells of the innate immune system (e.g. monocytes, macrophages and natural killer cells) are reprogrammed to respond differently to repeat exposures to microbial products and proinflammatory lipids.

This work is a collaboration among investigators at The Ohio State University, Case Western Reserve University, and the Joint Clinical Research Center/ Makerere University, Kampala, Uganda. Drs. Funderburg and Sahera Dirajlal-Fargo (CWRU) have been studying the immune and metabolic profiles of this cohort for several years as part of Dr. Dirajlal-Fargo's previous K award. This initial study identified several differences in these indices between children with and without PHIV, including evidence of heightened monocyte and T cell activation and alterations in lipid profiles and gut barrier function among the children with HIV. Dr. Liyanage will bring his expertise in natural killer (NK) cell biology to expand the team's ability to examine immune cell phenotypes and function.

This U01 award will enable the investigators to continue to examine immune profiles longitudinally in adolescents with and without HIV in Uganda and perform comparison studies to immune profiles from a cohort of HIV infected adolescents in the United States. This study combines *ex vivo* and *in vitro* assessments of immune cell phenotype and function using high-dimensional flow cytometry analyses, single cell transcriptional profiling, and an in-depth analytical approach to define the potential mechanisms whereby chronic exposure to ART, microbial products, and clinical and environmental factors may contribute to innate immune cell activation or dysfunction. The investigators hope that the knowledge gained from this work will lay the foundation for identifying key pathways with biological, clinical, and prognostic relevance for adolescents who are advancing into adulthood and inform intervention trials to mitigate the development of comorbidities associated with immune activation.

Amit Sharma is awarded with NIH R56 grant to investigate determinants of retroviral replication in non-native hosts for modeling HIV infection

Dr. Amit Sharma, Assistant Professor of Department of Veterinary Biosciences and Microbial Infection and Immunity has been awarded with an NIH R56 grant of $679,686 to study HIV and host interactions.

HIV does not persistently infect macaques due to restriction by several species-specific host factors necessitating the use of chimeric SIV/HIV viruses (SHIVs) as surrogates to model HIV infection in macaques. Infection of macaques with SHIVs is the preferred model system for vaccine and prevention studies because SHIVs encode HIV Envelope glycoprotein (Env) — the sole target of HIV neutralizing antibodies. Because the goal of vaccines is to prevent new infection, SHIVs based on circulating, transmitted forms of Env variants are desired as challenge viruses.

Existing SHIV/macaque models typically employ SHIVs that encode HIV Env from laboratory-adapted viruses, whose neutralization sensitivities differ from circulating Env variants. This significantly limits the ability of the existing SHIV/macaque models to predict efficacious intervention(s) in humans. Development of SHIVs encoding circulating Env variants has been extremely challenging, mainly because such SHIVs replicate poorly in macaques, if at all. To increase their replication and pathogenicity, SHIVs require extensive adaptation *in vivo* via serial passage in macaques.

The process of serial macaque passage results in accumulation of adaptive mutations in Env that facilitates robust replication.

Serial passage is typically performed within the first two weeks of infection, a time during which macaques mount a robust type-I interferon (IFN) response to infection. The host IFN response presents an early barrier against infection because production of IFNs upregulates expression of several IFN-stimulated genes (ISGs), which results in induction of an 'antiviral state'. Proteins encoded by certain ISGs, referred to as restriction factors, act as potent barriers against cross-species lentiviral transmission. Thus, macaque restriction factors have the potential to block SHIV infection as they can antagonize HIV Env. Dr. Sharma's research recently identified macaque interferon-induced transmembrane proteins (IFITMs) as ISGs that selectively restrict replication of SHIVs encoding circulating HIV Env variants.

Through the R56 grant, Dr. Sharma's group will characterize the adaptive changes in Env of serial passaged SHIVs that increase replication and IFN resistance and evaluate the contribution of macaque IFITM homologs in restriction of unpassaged, IFN-sensitive SHIVs. Upon completion, this study is expected to provide mechanistic insights at the host-viral interface that drive selection, adaptation and pathogenicity of SHIVs in macaques. This will in turn facilitate rational design of SHIVs that do not require extensive adaptation.

Patrick Green was awarded an NIH R13 meeting grant to help support 32nd International Workshop on Retroviral Pathogenesis

The International Workshop on Retroviral Pathogenesis has long served as a forum for the exchange of new research findings and concepts on all aspects of retroviral pathogenesis, particularly oncogenesis and immunodeficiencies, on topics ranging from molecular mechanisms to the immunological parameters of host-virus interaction.

The size and format of the conference, generally between 75 – 100 attendees, supports concentrated interaction and deep engagement over four days.

Pathogens of humans and animals in all retroviral genera are the subject of scientific presentation and vibrant discussion. The conference has long fostered the professional development of junior investigators by affording them the opportunity to present their current work to a panel of engaged colleagues, many of whom will be assessing their work through peer review, and to serve as Session Chairs.

The 32nd Workshop was held October 12-16, 2022 in Vail, Colorado (local host: University of Colorado). The 33rd Workshop is scheduled for December 4-7, 2023 in Trento, Italy (local host: University of Trento).

Karin Musier-Forsyth and colleagues renew HIV Structural Biology U54 Center Grant

Dr. Karin Musier-Forsyth, Professor and Ohio Eminent Scholar, Department of Chemistry and Biochemistry, has been awarded a five-year subcontract as part of the new "Behavior of HIV in Viral Environments" (B-HIVE) Center (2022-27). The Center PI is Dr. Bruce Torbett (Seattle Children's Research Institute, Seattle, WA).

The overall objective of this NIAID-sponsored Center is to further the understanding of HIV-1 and its interactions with cellular host factors within distinct cellular environments that shape the HIV replication cycle. With the limited size of the HIV RNA genome, it is no surprise that many of the same gene products end up performing different functions in different cellular environments at different times during replication. These various HIV-1-cell host factor interactions promote cellular pathogenesis and diseases characteristic of HIV-1/AIDS. Building on ten successful years of research from the HIVE Center, B-HIVE members collaboratively explore three complementary projects that focus on specific stages of the viral replication cycle.

Dr. Musier-Forsyth's main focus is to study the dynamics of HIV-1 packaging and assembly, including investigating the mechanism of HIV-1 RNA genome packaging and the proteins complexed with HIV-1 RNA; probing the cellular dynamics of the interactions between HIV-1 Gag and identified cellular factors that alter HIV-1 production; and elucidating the dynamics of Gag assembly and particle formation. She also co-directs the Biophysics Core aimed at providing Center members with expertise and support in biophysical methods including RNA structure-probing, single molecule approaches, live-cell imaging/microscopy, and native mass spectrometry.

Another major objective of the B-HIVE Center is to recruit and train talented scientists, graduate students and support staff who share a commitment in promoting equity, diversity and inclusion. The Center sponsors regular training workshops in technologies at the cutting-edge of structural biology, biophysics and computational methods.

Cody Warren joins The Ohio State University and the Center

Cody Warren, PhD., MPH, was recruited to join the Department of Veterinary Biosciences in the College of Veterinary Medicine and the Center for Retrovirus Research. Dr. Warren received his doctoral degree at the University of Colorado Anschutz Medical Campus in the laboratory of Dr. Dohun Pyeon, where his dissertation focused on the roles of APOBEC3 enzymes in human papillomavirus restriction, evolution and cancer progression. As a postdoctoral fellow in the laboratory of Dr. Sara Sawyer at the University of Colorado Boulder, he studied the evolutionary and biological bases of primate lentivirus (HIV/SIV) spillover into new host species. Dr. Warren received numerous training fellowships as a postdoctoral fellow for his studies of virus spillover, including NIH T32, F32 and K99/R00 awards.

Dr. Warren has studied the molecular interactions made between primate lentivirus Env proteins and its cellular receptor, CD4. His work described how CD4 diversity constrains the ability of primate lentiviruses to infect new host species. Furthermore, he uncovered an evolutionary ancient host virus arms race between CD4 and primate lentiviruses, providing important insights into cellular mechanisms of host resistance against immunodeficiency virus infections.

The Warren Research Group uses knowledge gained through the analysis of structure, function and host-virus interactions to identify fundamental biological processes that influence virus spillover. Furthermore, he employs population-level and evolutionary biology guided approaches to uncover the complex co-evolutionary dynamics at play between viruses and their hosts. Dr. Warren is eagerly seeking collaboration with other members of the Center for Retrovirus Research and is actively recruiting talented students and postdocs.

Welcome Cody!

The Center for Retrovirus Research
2022 Distinguished Research Career Award

Dr. Kathleen Boris-Lawrie was selected by the Center for Retrovirus Research of The Ohio State University to receive the 2022 Distinguished Research Career Award in recognition of her seminal contributions to the field of retroviruses, including our understanding of mRNA capping and the regulation of specialized translation.

Dr. Boris-Lawrie earned her B.S. and M.S. in microbiology from Southern Illinois University and Ph.D. in Molecular Genetics from George Washington University School of Medicine (1991) in collaboration with the National Cancer Institute, NIH. Next, she joined the laboratory of Dr. Howard Temin, 1975 Nobel Laureate in Medicine or Physiology, at the University of Wisconsin. During her postdoctoral training, Dr. Boris-Lawrie invented novel structural gene vectors covered by US patents and replication-defective vaccine vectors that lacked pathogenicity and protected against challenge with parental virus in animal models. In 1996, Dr. Boris-Lawrie joined the faculty of the Departments of Veterinary Biosciences and Molecular Virology, Immunology & Medical Genetics at The Ohio State University. She rose through the ranks and also served as the founding Executive Director of the Ohio State Life Sciences Network (2012-2015). In 2015, she moved to the Department of Veterinary & Biomedical Sciences at the University of Minnesota, where she served as Department Chair (2015-2020).

Dr. Boris-Lawrie's research is focused on unraveling genetic, biochemical and biophysical properties of the viral RNA-host protein interactions that promote or restrict viral infection. In ground-breaking work, Dr. Boris-Lawrie discovered a new class of post-transcriptional control element (PCE) in retroviruses and select host mRNAs. Her research identified PCE structure-dependent binding of nuclear RNA helicase A/DHX9 is necessary for translation of virion proteins and cancer-associated host transcription factors. Her studies characterized a novel cap-binding complex that cells use to overcome global translation inhibition, resolving the long-standing question of how protein synthesis is maintained during inhibition of mTOR. She showed that a hypermethylated cap structure of HIV-1 mRNA licenses its specialized translation pathway.

Together with her mentees and collaborators, Dr. Boris-Lawrie has published 70 primary research articles, reviews and book chapters. Dr. Boris-Lawrie's

Dr. Kathleen Boris-Lawrie holds the 2022 Distinguished Career Award crystal.

distinguished honors and awards include the 2001 Pfizer Animal Health Award for Research Excellence, the 2006 Outstanding Woman in Science Award from the Association for Women in Science of Central Ohio, and the 2006 Charles C. Capen Teaching Excellence Award for Graduate Education at Ohio State. She was elected as Fellows of the American Association for the Advancement of Science (2007) and the American Association for Microbiology (2011), named as a State-of-the-Art lecturer by the American Society for Virology (2009), and appointed David White Professor by the College of Veterinary Medicine at Ohio State (2008-2011). Dr. Boris-Lawrie has served on many NIH study section panels including service as a member of the Virology B scientific review group (2007-2011). She was appointed to the NIH Recombinant DNA Advisory Committee (2016-2020) and currently serves on the NIH Director's Novel and Exceptional Technology and Research Committee (2020-2023). Dr. Boris Lawrie was co-organizer of the 2015 Cold Spring Harbor Laboratory Retroviruses Meeting and has served as session chair or invited speaker at numerous additional international symposia.

Dr. Boris-Lawrie's distinguished award lecture was entitled "Unexpected roles for hypermethylated cap and nuclear proteins in HIV-1 and host mRNA translation." Her visit was sponsored by the Center for Retrovirus Research, Department of Veterinary Biosciences, Infectious Disease Institute, and the Comprehensive Cancer Center.

Shan-Lu Liu's research on COVID-19 vaccine is highlighted by NIH Director and national media, demonstrating that booster vaccination is needed for broad protection against omicron subvariants

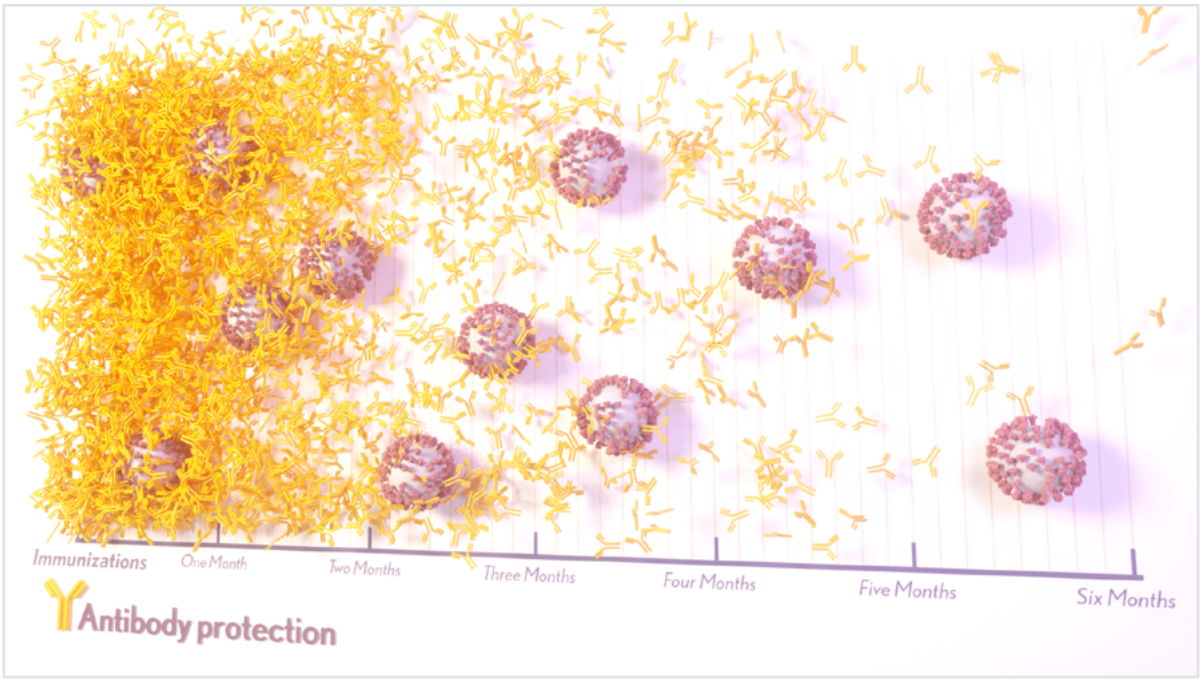
While mRNA vaccine is highly effective and has saved millions of lives around the world, boosters are needed to keep up the neutralizing antibody (nAb) levels to maintain the protection. In a series of studies published by **Shan-Lu Liu** and colleagues in Science Translational Medicine, New England Journal of Medicine, Cell Host & Microbe, and Science Immunology, etc. showed that the nAb levels from the original two-dose mRNA vaccine is completely ineffective against Omicron and does not induce mucosal immunity, and that nAb levels generated by first booster also rapidly decline, by ~17-20 percent per month, indicating that additional boosters, likely by FDA-approved new formulation containing BA.5, are needed.

"The message from our study is clear: If you have a dramatic loss of antibodies from the first booster, you definitely need a second booster to get antibodies back," said Shan-Lu Liu, senior author the study and a virology professor in the Center for Retrovirus Research and Department of Veterinary Biosciences at The Ohio State University.

"It's not surprising to us to find that we see this antibody decline — in general, vaccine-induced antibodies decline over time regardless of the virus, and especially if the virus changes over time in the way that SARS-CoV-2 has changed," said Liu, who is also Co-director of the Viruses and Emerging Pathogens Program of Infectious Diseases Institute.

Liu's research paper on the initial emergence of new Omicron variants BA.1.1 and BA.2 was published in Cell Host & Microbe and reported in AP News. His subsequent research on the waning of neutralizing antibody response from the two-dose COVID vaccination was published in Science Translational Medicine and highlighted in NIH Director's blog. Liu's additional three NJEM letters and one additional paper in Cell Host & Microbe showing the neutralization resistance of BA.4/5 and BA.2.12.1, Deltacron, as well as the durability of the first booster provide critical insights and guidance for COVID-19 vaccination strategy. Most recently, his publication in Cell Host & Microbe showing continuing threats of new Omicron subvariants BQ.1 and BQ.1.1 to COVID-19 vaccine was reported by NBC National News and The Daily Beast.

For additional information, read Ohio State news releases: COVID booster needed for broad protection against omicron variants, Neutralizing antibodies from single COVID-19 booster steadily decline, and A growing trend of antibody evasion by new omicron subvariants.



Selected Grants and Recognitions

U01AI168630-01 (**Nicholas Funderburg / Namal Liyanage**)
The role of Trained Immunity and Mitochondrial dysfunction on INnate immunity in children and adolescents aGing with PHIV (TIMING-PHIV) (2022-2027)

NIH U54 AI170855 (subcontract PI and Biophysics Core co-leader: **Karin Musier-Forsyth**)
Behavior of HIV in Viral Environments (B-HIVE Center PI: Bruce Torbett) (2022-2027)

NIH R56 AI172615 (**Amit Sharma**)
Determinants of Retroviral Replication in Non-native Hosts for Modeling HIV Infection" (2022-2023)

Ohio State CCC Leukemia Research Program Seed Grant (**Amanda Panfil / Stefan Niewiesk**)
Preventative Human T-cell Leukemia Virus Type 1 Vaccine (2022)

Cystic Fibrosis Foundation Path to a Cure Pioneer Award (**Kristine Yoder**)
This project is to identify ambitious basic research projects aiming to utilize cutting-edge techniques and strategies that have the potential to discover new genetic-based therapies for cystic fibrosis.

Ohio State IDI Seed grant (**Ross Larue**)
Development of Small Molecule HIV-1 Capsid-targeting Probes (2022-2023)

Ohio State IDI Office of Knowledge and Enterprise Presidential Accelerator Grant (**Ross Larue**)
Small Molecule Inhibitors for Directed Targeting of BET/Brd4 Extra-Terminal Domain as a Novel Cancer Therapeutic (2022)

NCI U54 CA260582-Cancer Suppl (**Shan-Lu Liu**)
This U54 supplementary grant is to study the immune response in cancer patients. (2022-2023)

NCI U54 CA260582-Case Western Suppl (**Shan-Lu Liu**)
This U54 supplementary grant is to collaborate with Case Western Reserve University for study of COVID patients in nursing homes. (2022-2023)

American Society of Radiologic Technologists (ASRT) Foundation (**Namal Liyanage**)
Novel Diagnostic Assessment of Pediatric COVID Survivors: Managing Chronic COVID Symptoms (2022-2023)

MII Pilot funding (**Namal Liyanage**)
Investigate the Link Between Dysregulated Immune Responses and Cardiovascular Risk in COVID-19 survivors (2022)

IDI Host Defense and Microbial Biology Grant (**Namal Liyanage**)
Identify the HIV Vaccines Induced NK cell Responses (2021-2022)

R13CA277752 (**Patrick Green**)
32nd International Workshop on Retroviral Pathogenesis (2022)

2022 NIAID Merit Award (**Kai Xu**)
Kai Xu is recipient of NIAID Merit award as a special volunteer of the Structural Biology and Informatics Vaccine Research Team.

Lead Inventor for Provisional Patent (**Amit Sharma**)
Small Molecule Inhibitors for the Treatment and Prevention of Coronavirus Infection

Provisional patent (**Amanda Panfil**, **Patrick Green**, **Stefan Niewiesk**); Preventative human T-cell leukemia virus type 1 vaccine

Kristine Yoder appointed to the NIH HVCD study section

Kristine Yoder is a co-organizer of the 7th International Conference on Retroviral Integration July 31 to August 4, 2023 in Boulder, Colorado. retrointegration2023.org
Other organizers are Mamuka Kvaratskhelia, Alan Engelman, Duane Grandgenett, and Goedele Maertens.

Amit Sharma is invited Session Chair of the Pathogenesis and Immunity session in 32nd International Workshop on Retroviral Pathogenesis.

Amit Sharma is Associate Editor of Frontiers in Cellular and Infection Microbiology.

Shan-Lu Liu is the local host of the 2024 ASV annual meeting in The Ohio State University, Columbus.

Karin Musier-Forsyth is co-organizer of the 12th Retroviral Symposium: Assembly, Maturation and Uncoating, Sept 6-9, 2023, Snowbird, Utah. Other organizers are Saveez Saffarian, Eric Freed, Delphine Muriaux, and Mark Williams.

Graduate Student, Post-doc and Research Scientists Awards

Christina Ross (Musier-Forsyth lab) was awarded a CMBP T32 Fellowship 2022-23

Morgan Bauer (Musier-Forsyth lab) was awarded a CMBP T32 Fellowship 2022-23

Kaylee Grabarkewitz (Musier-Forsyth/Wysocki labs) was awarded a MBTP T32 Fellowship 2022-24

Joe Kanlong (Musier-Forsyth lab) was awarded a MBTP T32 Fellowship 2022-24

Amanda Midkiff (Panfil lab) was awarded an AVMA/AVMF 2nd Opportunity Summer Research Scholarship; recipient of the 2022 Gertrude Hoeger Biomedical Research Award for the Basic Research Category

Kyle Ernzen (Panfil lab) was awarded a Cellular, Molecular and Biochemical Sciences Program (CMBP) T32 Fellowship

Susan Smith (Panfil & Green lab) was awarded a 2022 ACVP Young Investigator Award

Emily King (Panfil lab) was awarded a 2022 ACVP Young Investigator Award (clinical faculty mentor: Ryan Jennings)

Emily King (Panfil lab) was awarded an OSU Dean's Distinguished University Fellowship

Zachary Horwitz, **Rebecca Morton**, **Riya Patel**, **Jacob Russo**, and **Ryan Scheutter** (Yoder lab) were awarded Ohio State Undergraduate Research Apprentice Program summer fellowships

Riya Patel (Yoder's lab) was awarded an Ohio State CCC Pelotonia Undergraduate Fellowship

Jack Evans (Liu lab) was a recipient of the 2022 ASV travel award

Julia Faraone (Liu lab) was a recipient of the 2022 ASV travel award

Graduate Student and Post-doc Career Moves and Positions

Aaren Kettelhut (Funderburg lab) graduated spring 2022 and returned to medical school to finish her MD-PhD program.

Cong Zeng (Liu lab) was appointed as an independent PI and professor at Fudan University.

Minghua Li (Liu lab) started as tenure-track assistant professor at the University of Texas Medical Branch.

Jingyou Yu (Liu lab) lab became an independent PI and professor of National Nanfang Laboratory of China.

Kun Li (Liu lab) became an independent PI and BSL3 core director of Cleveland Clinic Florida.

Danni Jin (Musier-Forsyth lab) is a postdoctoral researcher in the lab of Wendy Gilbert at Yale University.

Yingke Tang (Musier-Forsyth lab) is a patent associate for JunHe LLP in Shanghai, China.

Meeting Announcements

Cold Spring Harbor Laboratory "Retroviruses"
May 22-27, 2023, Cold Spring Harbor, NY

42nd ASV annual meeting
June 24-28, 2023, University of Georgia, GA

The 7th International Conference on Retroviral Integration
July 31 - August 4, 2023 in Boulder, Colorado.
retrointegration2023.org

The 12th Retroviral Symposium: Assembly, Maturation and Uncoating
Sept 6-9, 2023, Snowbird, Utah

33rd International Workshop on Retroviral Pathogenesis
December 4-7, 2023, Trento, Italy

2022 Graduates and Passage of Candidacy Exam

Jun-Kyu Byun
(Musier-Forsyth lab) successfully completed PhD

Yu-Ci Syu
(Musier-Forsyth lab) successfully completed PhD

Kyle Ernzen
(Panfil lab) successfully passed PhD candidacy

Julia Faraone
(Liu lab) successfully passed PhD candidacy

Sarah Golconda
(Kim Lab) successfully passed PhD candidacy

Susan Smith
(Panfil & Green lab) successfully passed PhD candidacy

Megan Sullivan
(Musier-Forsyth lab) successfully passed PhD candidacy

Rylan Watkins
(Musier-Forsyth lab) successfully passed PhD candidacy

Selected Publications

Abdelhamid, A. G, J. N. Faraone, J. P. Evans, **S.-L. Liu**, and A. E. Yousef. 2022. SARS-CoV-2 and Emerging Foodborne Pathogens: Intriguing Commonalities and Obvious Differences. *Pathogens*. July 27, 2022. doi. org/10.3390/pathogens11080837.

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Evans J. P, P. Qu, C. Zeng, Y.-M. Zheng, C. Carlin, J. S. Bednash, G. Lozanski, R. Mallampalli, L. J. Saif, E. M. Oltz, P. Mohler, R. J. Gumina, and **S.-L. Liu. *** 2022. Neutralization of SARS-CoV-2 Deltacron and BA.3 Variants. *New England Journal of Medicine*. 386: 2340-2342.

Evans J. P, C. Zeng, P. Qu, J. Faraone, Y.-M. Zheng, C. Carlin, J. S. Bednash, T. Zhou, G. Lozanski, R. Mallampalli, L. J. Saif, E. M. Oltz, P. Mohler, **K. Xu**, R. J. Gumina, and **S.-L. Liu. *** 2022. Neutralization of SARS-CoV-2 Omicron Sub-lineages BA.1, BA.1.1 and BA.2. *Cell Host & Microbe*. S1931-3128(22)00220-7.

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Selected Publications - continued

Mycobacterium bovis BCG and vaccine candidate BCGΔBCG1419c. *Sci Rep*. 2022 Jul 20;12(1):12377. doi: 10.1038/s41598-022-14935-y.PMID: 35858977.

Gyang, TC, J. P. Evans, J. Miller, K. Alcorn, J. Peng, E. Bell, C. Zeng, R. J. Gumina, and **S.-L. Liu***, and B. Segal*. Efficacy of SARS-CoV-2 Vaccination in Patients with Multiple Sclerosis. *Multiple Sclerosis Journal-Experimental, Translational and Clinical*. 8(1): 20552173221087357. 2022 Mar 22;8(1):20552173221087357.

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