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Before the
Subcommittee on Energy
Committee on Science, Space and Technology
U.S. House of Representatives

"Biological Research at the Department of Energy: Leveraging DOE's Unique Capabilities to Respond to the COVID-19 Pandemic"

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Chairman Fletcher, Ranking Member Weber, and Members of the Subcommittee, thank you for the opportunity to participate in today's discussion about Biological Research at the Department of Energy: Leveraging DOE's Unique Capabilities to Respond to the COVID-19 Pandemic.

I am Glenn Randall, a Professor of Microbiology and Chair of the Committee on Microbiology at The University of Chicago, where I have studied emerging RNA viruses for the past 15 years. I am also the Director of Emerging Infections at the Howard Taylor Ricketts Regional Biocontainment Laboratory. This is one of thirteen National Institutes of Health-funded Regional Biocontainment Laboratories built to sustain research with pathogens that require enhanced biosafety (Biosafety Level 3), such as SARS-CoV-2, the causative agent of the COVID-19 pandemic. This facility is operated by the University of Chicago. There are a limited number of Biosafety Level 3 facilities in the United States. I direct a COVID-19 research core at this facility. The purpose of this core is to facilitate the COVID-19 research of other scientists, who need us to do experiments with live virus under enhanced safety conditions that they cannot do themselves due to a lack of expertise or facilities. This research is primarily focused on evaluating potential treatments and vaccines for SARS-CoV-2. It is in this capacity that I have gained an appreciation of the value of COVID-19 research performed in the Department of Energy. In particular, I have enjoyed multiple productive COVID-19-related collaborations with scientists at the DOE Argonne National Laboratory.

The U.S. Department of Energy Office of Science's Biological and Environmental Research (BER) program has a storied history. Decades ahead of the curve, it embraced inter-disciplinary science. It integrated biologists, physicists, computer scientists and engineers to address some of the most important questions of today and tomorrow. It is specifically designed to answer questions larger than one field can answer, such as our current pandemic. The needs are vast: effective drugs (both against the virus and to treat

the symptoms), a vaccine (both effective initially and likely better generations of vaccines in the future that provide long-lasting protection), and drugs and vaccines that will also protect against coronaviruses that will emerge in the future. Additional issues include more and better personal protective equipment (PPE) for our front-line health care workers. Moreover, coronaviruses are not our only pandemic threat. Influenza virus, as one example, will almost certainly cause a new pandemic in the not too distant future.

Many of the extraordinary capabilities that BER has nurtured have been foundational to a specific response to COVID-19: The U.S. Department of Energy National Virtual Biotechnology Laboratory (NVBL), which is a consortium of all 17 DOE National laboratories, each with core capabilities relevant to the threats posed by COVID-19. They leverage expertise and technology that synergistically interact with each other, academia and industry to advance our fight against COVID-19. This effort capitalizes on long-held expertise in unequaled strengths, such as discovering the structure of proteins (what they look like and how to target them) and supercomputing to simulate billions of potential drug-target interactions that amplify our current pharmaceutical capabilities by orders of magnitude.

The NVBL effort focuses on the following areas: https://science.osti.gov/nvbl[1]

Molecular structural determination: X-ray sources and neutron sources at DOE user facilities provide protein crystal structures needed for both computational modeling and experimental studies related to drug and vaccine development. These include the Advanced Photon Source (APS) at Argonne, Advanced Light Source (ALS) at Lawrence Berkeley, Stanford Synchrotron Radiation Light Source (SSRL) at SLAC, the Linac Coherent Light Source at SLAC, National Synchrotron Light Source II (NSLS II) at Brookhaven, and Spallation Neutron Source (SNS) at Oak Ridge National Laboratories. In addition, cryo-electron microscopes can be used to provide high resolution structures of virus particles and their interactions with antibodies and other drugs. DOE's Nanoscale Research Science Centers provide additional capabilities for imaging and characterization, as well as materials synthesis and nanofabrication capabilities to support study of biomolecules.

The DOE X-ray and neutron sources are a long-held treasure for the biological sciences, in addition to many other disciplines. We mostly study proteins blindly, not knowing what they look like or how to target them with drugs. These groups provide us with a detailed picture of the target. Many structures of SARS-CoV-2's 30 proteins have been solved at these facilities, many by DOE staff. These protein structures allow predictions as to what types of drugs may be effective against SARS-CoV-2. Structures of SARS-CoV-2 proteins bound by drugs are also being solved to give us important clues as to how we can modify the drugs to be more effective. Similarly, the structure of antibodies bound to the viral Spike protein are solved to better understand how they neutralize infection. Every submitted SARS-CoV-2 manuscript thus far involving my group relies on this invaluable capability.

Computational modeling and simulation: High performance computing resources at DOE user facilities, employing artificial intelligence, molecular dynamics simulations, and

modeling tools, combined with input from protein structure data, provide information to support research related to rapid survey of existing drugs and development of anti-viral agents and vaccines.

Most pharmaceutical companies have a library of 1-3 million compounds to screen against a disease target of interest. The supercomputers of multiple DOE National Laboratories have collaborated to generate a virtual library of every known chemical (~5 billion) and then screen them by molecular docking computer simulations of potential drugs bound to the SARS-CoV-2 protein structures described above. This is done over multiple iterations using artificial intelligence and machine learning to identify the best drug candidates. Now that candidates have been identified computationally, we are currently helping this consortium experimentally screen ~1000 potential drugs for anti-SARS-CoV-2 activity.

Genomic sequencing: Genomic resources at DOE's Joint Genome Institute and other facilities can sequence large numbers of patient samples to identify constrained regions, compare COVID-19 with other genomes to identify candidate regions for immuno-targeting, and construct models of individual susceptibility.

This capability is important for tracking how SARS-CoV-2 evolves. We have already witnessed an example where a SARS-CoV-2 variant emerged in Europe and overtook most of the world, including the United States (D614G in Spike). This capability will prove more valuable as we track drug and vaccine resistant emergence in the months to some.

The NVBL also works in areas that don't currently involve me, but are no less important such as:

Epidemiological and logistics support: Proven capabilities based on data analytics, artificial intelligence, and other decision tools have previously supported many national emergencies including oil spills, hurricanes, DOD supply chains and epidemiology. These capabilities have been deployed for government agencies, such as DOE, FEMA, and DOD. Such tools can yield information for health care providers and government groups on modeling disease spread, collecting/analyzing information and data from open sources world-wide, and providing tools for real-time decision making, risk analysis and prioritization for patient care and supply chain logistics.

Knowledge Discovery Infrastructure / Scalable Protected Data (KDI/SPI): Specialized facilities consisting of a multi-tier architecture facilitating a private cloud environment are available to host protected health data for research and analysis. These facilities meet NIST 800.66 and 800.53 control sets that meet Federal Information System Management Act (FISMA) requirements for a classification of moderate with enhanced controls. These capabilities are currently being used by Veteran's Affairs, Center for Medicare & Medicaid Services, and the National Cancer Institute's Surveillance, Epidemiology, and End Results programs.

Supply Chain Bottlenecks: Extensive manufacturing capabilities across the DOE laboratory complex are addressing supply chain bottlenecks associated with COVID-19.

Guided by input from both public and private stakeholders (government, health care providers), three health care supply chain bottlenecks have been identified: surgical masks and face shields, ventilator systems, and consumables (swabs, test kits components) used in COVID testing. These DOE teams have capabilities to rapidly reverse engineer/design and manufacture prototype parts, dies, and molds for industrial scaling.

Testing of clinical and non-clinical samples: DOE laboratories have established deep capabilities in high throughput preparation and analysis of biological samples using PCR-based protocols. While currently used to support DOE's mission in energy science, these facilities and trained personnel can be deployed to help address the rising surge in clinical samples. In addition, many labs have expertise in sampling and analysis of surfaces for biological materials developed in support of DOE programs.

NVBL has also recently started a new project on understanding *SARS-CoV-2 viral fate and transport*. This research effort leverages capabilities in computational modeling, data science, chemistry, environmental science, material science, aerosol chemistry and modeling, indoor air quality science and bioaerosol facilities, genomics and biodefense and makes extensive use of DOE user facilities, biosafety level 3 (BSL 3) facilities, environment research facilities, and the computational infrastructure across the national laboratory complex, to address the open questions around mechnisms of SARS-CoV-2 transmission. Enhancing the potential to predict SARS-CoV-2 viability and transmission in built and natural environments will help inform approaches to interrupt the chain infections, as well as inform strategies that guide society's resumption of normal activities.

I thought the best way for me to discuss DOE's impact on COVID-19 is to describe four of my personal experiences working with them. The first two studies I will describe used the strategy of drug repurposing, which was the topic of a prior subcommittee hearing. The basic idea is that drug development is a lengthy process, beginning with biochemistry, virology, animal studies, and finally clinical trials. By repurposing already approved drugs, you can greatly accelerate this process. In the first study[2], DOE scientists at Argonne National Lab first described the structure of the SARS-CoV-2 protein Nsp15. They then developed biochemical assays to assess the activity of the protein. Based on structural similarities, they predicted that the FDA-approved drug Tipiracil would inhibit the activity of the protein, which it did. Although Tipiracil had limited antiviral activity in our assays, co-structures of the drug bound to Nsp15 suggest modifications to improve its antiviral activity.

In the second study[3], colleagues of ours at The University of Chicago screened a library of ~1900 FDA-approved drugs against the related coronavirus OC43, a cause of the common cold that can be worked with under standard biosafety conditions (BSL 2). We when tested the top 30 hits in their screen for anti-SARS-CoV-2 activity and identified 20 drugs, ~ half of which were not previously identified in the literature. Collaborators at The University of Chicago and Duke University tested the 20 drugs for activity against the major viral protease, 3CLpro. One drug in particular, Masitinib completely blocked 3CLpro and virus replication. Our colleagues at Argonne solved the structure of Masitinib bound to the active site of 3CLpro. You can think of it as a key that perfectly fits in a lock, inactivating the

protein and preventing infection. Two potential clinical trials have emerged from this study. One involves the manufacturer of Masitinib (AB Science). The second trial would be run out of the University of Chicago and examine the potential use of a nasal spray Azelastine as a preventative against COVID-19. As these drugs show activity against multiple coronaviruses, there is potential for stock-piling them for future pandemics.

The third study[4] included many of the same collaborators. A major drug target of SARS-CoV-2 is another protease called PLpro. Proteases are attractive, in part, because they have been successfully targeted by drugs to treat HIV and hepatitis C virus. Our collaborators at Argonne solved the structure of PLpro, while colleagues at The University of Chicago designed inhibitors against the protein and biochemical assays to test the potential drugs. They confirmed activity against PLpro and for some of the compounds, we showed activity against the virus. Finally, our Argonne colleagues solved structures of the drugs bound to PLpro, suggesting strategies to further improve them.

I have already described the final study, which is testing potential drugs identified by the NVBL Molecular Design for Medical Therapeutics project. The work is a little less developed on the biology side, as we have begun testing compounds in the past two weeks (it is quite advanced on the computing side). There are already clearly potential antiviral compounds in this group.

In the past few months, I have enjoyed my collaborations with the DOE labs at Argonne. The unique skill sets that they bring to COVID-19 research are valuable and impressive. My interactions have been with just a fraction of the capabilities that DOE brings to combat COVID-19. DOE work in epidemiology, patient databases, manufacturing to address supply chain bottlenecks in PPE and ventilators, and clinical sample testing address important complementary challenges present by the pandemic.

Thank you for the invitation to testify to the Subcommittee on Energy. I would be happy to answer any questions you or other members of the committee may have.

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Glenn Randall Bio

Glenn received his B.S. with distinction in Microbiology from the University of Illinois, Urbana-Champaign. After an internship at Abbott Laboratories, he pursued graduate studies at The University of Chicago in the laboratory of Bernard Roizman. His doctoral thesis describes mechanisms by which herpes simplex virus I establishes a latent infection. He then joined the Laboratory of Virology and Infectious Disease at Rockefeller University in New York. His American Cancer Society postdoctoral fellowship was under the mentorship of Charles Rice. His research focused on hepatitis C virus (HCV)-host interactions with an emphasis on the interaction between HCV and cellular RNA interference (RNAi) pathways. He joined the Department of Microbiology at the University of Chicago in August of 2005. Since joining The University of Chicago, Glenn has received numerous awards, including the Schweppe Fellowship, the American Liver Foundation Heman Lopata Hepatitis C Scholar, The University of Chicago DDRCC Outstanding New Investigator, a Career Development Award from the Great Lakes Center for Excellence (NIH/NAIAD) and an American Cancer Society Research Scholar Award. In 2019 he was promoted to Professor and in 2020 appointed Chair of the Committee on Microbiology. In 2020 he was also appointed as the Director of Emerging Infection Research at the Howard Taylor Ricketts Regional Biocontainment Laboratory where he leads COVID-19 research.

Glenn's laboratory investigates the roles of virus-host interactions in replication and pathogenesis. They study emerging RNA viruses, including hepatitis C virus, dengue virus, norovirus, and SARS-CoV-2. They now study the importance of cellular genes in diverse steps of the viral life cycle, including entry, the regulation of viral protein translation and RNA replication, modulation of cellular lipid metabolism, the establishment of viral replication complexes, the secretion of infectious virus, and control of infection by the innate immune system.

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ACADEMIC APPOINTMENTS

2005-12	Assistant Professor, Department of Microbiology, The University of Chicago
2012-	Associate Professor (tenured), Department of Microbiology, The University of Chicago
2019-	Professor, Department of Microbiology, The University of Chicago

Ph.D.-Granting Committee, Program, Institute, and Center Appointments

2006-	Committee on Microbiology
2006-	Digestive Disease Research Core Center
2006-	Trainer on 6 NIH training grants: Host-Pathogen Interactions, Molecular & Cellular Biology, Medical Scientist NRSA, Immunology, Gastrointestinal, Initiative Maximizing Student Development
2007-	Investigator, University of Chicago Cancer Research Center
2007-	Committee on Immunology

ACADEMIC TRAINING

1989-1993	B.S., Microbiology. University of Illinois, Urbana Champaign, IL
1993-1999	Ph.D., Virology, The University of Chicago, Chicago. IL
2000	Postdoctoral Researcher, The University of Chicago, Chicago. IL
2000-2005	Postdoctoral Fellow, Rockefeller University, New York, NY

SCHOLARSHIP

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45. Xiao, F., S. Wang, V. Nicolaescu, R. Barouch-Bentov, G. Neveu, S. Pu, M. Beer, S. Schor, **G. Randall***, and S. Einav*. 2018. Interactions between the hepatitis C virus nonstructural 2 protein and host adaptors 1 and 4 orchestrate virus release. mBio. 9(2) pii:e02233-17.

* Equal contribution

46. **Randall, G.** 2018. Lipid droplet metabolism during dengue virus infection. Trends in Microbiology. 26:640-642.

47. Kincaid R.P., V.L. Lam, R.P. Chirayil, **G. Randall** and C.S. Sullivan. 2018 RNA triphosphatase DUSP11 enables exonuclease XRN-mediated restriction of hepatitis C virus. Proc. Natl. Acad. Sci. USA. 115:8197-8202.

48. Baktash, Y. and **G. Randall.** 2019. Live cell imaging of hepatitis C virus trafficking in hepatocytes. Methods Mol. Biol. Doi:10.1007/978-1-4939-8976-8_18.

49. Zhang Z, He G, Filipowicz NA, **Randall G**, Belov GA, Kopek BG, Wang X. 2019. Host Lipids in Positive-Strand RNA Virus Genome Replication. Front Microbiol. 2019 Feb 26;10:286. doi: 10.3389/fmicb.2019.00286.

50. Ketter, E. and **G. Randall** 2019. Virus Impact on Lipids and Membranes. Annu Rev Virol. 6(1):319-340. doi: 10.1146/annurev-virology-092818-015748.

51. K, SB Biering, J Choi, CB Wilen, RC Orchard, CE Wobus, CA Nelson, DH Fremont, MT Baldridge, **G Randall**, S Hwang. 2020. CD300LF Polymorphisms of Inbred Mouse Strains Confer Resistance to Murine Norovirus Infection in a Cell Type-Dependent Manner. Furlong J Virol. 2020 Aug 17;94(17):e00837-20

(b) Peer-reviewed works in 'non-traditional' outlets: N/A

(c) Peer-reviewed works accepted or in press: N/A

(d) Non-peer-reviewed original articles

52. Kim Y, J Wower, NI Maltsev, C. Chang, Robert Jedrzejczak, M Wilamowski, **G Randall**, K Michalska and A Joachimiak. Tipiracil binds to uridine site and inhibits Nsp15 endoribonuclease NendoU from SARS-CoV-2. bioRxiv 2020.06.26.173872; doi: https://doi.org/10.1101/2020.06.26.173872

53. Osipiuk, J, SA Azizi, S Dvorkin, M Endres, R Jedrzejczak, KA Jones, S Kang, RS Kathayat, Y Kim, VG Lisnyak, SL Maki, V Nicolaescu, CA Taylor, C Tesar, YA Zhang, Z Zhou, **G Randall**, K Michalska, SA Snyder, BC Dickinson, A Joachimiak. Structure of papain-like protease from SARS-CoV-2 and its complexes with non-covalent inhibitors. doi: https://doi.org/10.1101/2020.08.06.240192

54. Drayman, N, KA Jones, SA Azizi, HM Froggatt, K Tan, NI Maltseva, S Chen, V Nicolaescu, S Dvorkin, K Furlong, , RS Kathayat, MR Firpo, EA Bruce, MM Schmidt, R Jedrzejczak, MA Muñoz-Alía, B Schuster, V Nair, JW Botten, CB Brooke, SC Baker, BC Mounce, NS Heaton, B Dickinson, A Jaochimiak, **G Randall** and Savaş Tay. Drug repurposing screen identifies masitinib as a 3CLpro inhibitor that blocks replication of SARS-CoV-2 and other viruses. bioRxiv. doi:https://doi.org/10.1101/2020.08.31.274639

(e) Books:

55. Grakoui, A, JM Pawlotsky and **G. Randall**. Hepatitis C Virus: The Story of a Scientific and Therapeutic Revolution . Cold Spring Harbor Laboratory Press.

(f) Book chapters:

56. Rice, C. M., You, S., **Randall, G**, Zhang, J., McMullan, L. K., Marcello, T., Grakoui, A., Hanson, H. L., Moradpour, D., Lindenbach, B. D., & McKeating, J. A. (2004) Hepatitis C: unraveling the details of hepatitis C virus replication and immunity. In, "Viral Hepatitis and Liver Disease". Jilbert, A. R., Grgacic, E. V. L., Vickery, K., Burrell, C. J., and Cossart, Y. E. eds. Proceedings, 2003 International Symposium on Viral Hepatitis and Liver Disease.1.

57. **G. Randall.** 2013. Basic Virology. In Jensen, D. and N. Reau, Hepatitis C. Oxford American infectious disease library. Oxford University Press. ISBN 978-0-19-984429-6.

58. Jordan, T.X. and **G. Randall**. 2015. Flaviviruses and autophagy. In Jackson, W.T. and M. Swanson. Autophagy, Infection, and the Immune Response p. 81-100. Wiley-Blackwell**.** ISBN: 978-111867755-1;978-111867764-3.

59. Shulla, A. and **G. Randall.** Hepatitis C virus-host interactions. 2016. In Walker, C, T. Miyamura, S. Lemon, and T. Wakita. Hepatitis c virus I: cellular and molecular virology. P. 197-233. Springer Japan. ISBN: 978-443156098-2;978-443156096-8.

60. **G. Randall.** 2018. Basic Virology. In Jensen, D. and N. Reau, The New Hepatitis C. Oxford American infectious disease library. 2nd. Edition. Oxford University Press. ISBN 978-0-19-984429-6.

61. Lindenbach, B.S., **G. Randall**, R. Bartenschlager & C.M. Rice. 2019. Flaviviridae: The viruses and their replication. In Field's Virology 7th edition. Volume 1: Emerging Viruses. Ed. PM Howley, DM Knipe. Wolters Kluwer

(g) Other works that are publically available (websites, interviews, publications in the popular press, testimony, computer programs, protocols, reagents, inventions, patents not listed above, etc.) N/A

Provisional Patent UCHI 20-T-062. "Inhibition of Nidoviruses That Encode NSP15."

Provisional Patent UCHI 21-T-017. "Repurposing drugs to prevent or treat COVID-19."

(h) Clinical trials that are ongoing and unpublished. N/A

(j) Works in review, in preparation, etc. not yet publically available [list ONLY if available for BSD review]

Brown, R.J.P., J. Sheldon, T. Khera, A. Kusuma, R. Weller, D. Todt, G. Vieyres, B. Tegtmeyer, Svenja Wiechert, D. Bankwitz, K. Welsch, M. Engelmann, C. Ginkel, E. Steinmann, Q. Yuan, M. Ott, F. Vondran, T. Krey, L. Stroeh, N. Goedeke, D. Wirth, V. Herder, W. Baumgärtner, C. Lauber, A. Tarr, **G. Randall**, Y. Baktash, A. Ploss, B. Heller, B. Winer, M. Saeed, V.L.D. Thi, E. Michailidis, C.M. Rice and T. Pietschmann. In revision. Science Advances. Constitutively expressed, non-interferon inducible factors *CD302* and *CR1L* block Hepatitis C virus infection of murine hepatocytes.

FUNDING

(a) Past:	Term	Annual Direct Costs
1R01DK102883-01A1 (Randall, PI) NIH/NIDDK "Hepatocyte remodeling by hepatitis C virus" Role: Principal Investigator (30% effort)	4/1/15-3/31/20(NCE)	$225,000

2R56AI080703-06A1 (Randall, PI) 3/1/17-10/31/18 $250,000
NIH/NIAID
"Hepatitis C virus trafficking in infected hepatocytes"
Role: Principal Investigator

RSG-14011 0-01-MPC (Einav, PI) 7/1/14-6/30/18 $16,226
American Cancer Society
"Roles of clathrin adaptor proteins-mediated pathways in hepatitis C virus infection"
Role: Co-investigator

R01AI080703, (Randall, PI) 5/1/10-4/30/15 $225,000
NIH/NIAID
"Hepatitis C virus trafficking in hepatocytes"
Role: Principal Investigator (40% effort)

118676-RSG-10-059-01-MPC (Randall, PI) 1/1/10-12/31/13 $180,000
American Cancer Society
"Membrane remodeling in hepatitis C virus infection"
Role: Principal investigator (20% effort)

R21 AI102236-01 (Randall, PI) 7/1/12-6/30/14 $133,500
NIH/NIAID
"Fatty Acid Synthase Inhibitors As Broad Spectrum Anti-Flaviviral Therapeutics"
Role: Principal Investigator (15% effort)

U54AI057153 DP8 (Schneewind, PI) 3/1/11-2/28/13 $125,000
NIH/NIAID Great Lakes Regional Center for Excellence
"Identification and Characterization of Dengue Virus Receptors"
Role: Principal Investigator (10% effort)

NIH U54AI057153 CDP (Schneewind, PI) 3/1/08-2/28/11 $115,000
NIH/NIAID Great Lakes Regional Center for Excellence
"Membrane re-organization in Dengue virus replication"
Role: Principal Investigator (50% effort)

1R56AI080703-01 (Randall, PI) 9/4/09-4/30/10 $250,000
NIH/NIAID
"Hepatitis C virus trafficking in infected hepatocytes"
Role: Principal Investigator (10% effort)

American Liver Foundation Hepatitis C Scholar 7/1/07-7/31/09 $75,000
"USP18 as a target to improve interferon therapy of HCV"
Role: Principal Investigator (50% effort)

Schweppe Foundation New Investigator Award 4/1/07-3/1/09 $50,000
"Modulation of innate immunity to hepatitis C virus infection"
Role: Principal Investigator (1% effort)

Outstanding New Investigator 12/1/06-11/30/08 $62,700
NIH/NIDDK Digestive Disease Research Core Center
"Identifying hepatocytes membrane trafficking pathways critical for
hepatitis C virus infection of the liver."
Role: Principal Investigator (30% effort)

American Cancer Society Institutional Research Grant 12/1/06-11/30/07 $20,000
University of Chicago Cancer Research Center
"Identifying hepatocyte membrane trafficking pathways critical for hepatitis C virus infection of the liver."
Role: Principal Investigator

PF-20-016-01-MBC (Randall, PI) 1/1/02-12/31/04 $39,300
American Cancer Society Postdoctoral Fellowship
"Modulation of cell receptor expression by hepatitis C virus NS5A protein"

(b) Current:

	Term	Annual Direct Costs
1R01AI137514-A1 (Randall, PI) NIH/NIAID "Hepatitis C virus trafficking in hepatocytes" Role: Principal Investigator (20% effort)	3/5/19-2/29/24	$250,000
1R01AI134980-A1 (Sullivan, Randall PI) NIH/NIAID "Elucidating how tri-phosphatase DUSP11 controls HCV infection and hepatocyte inflammation" Role: Co-PI, Multi-PI (20% effort)	8/1/18-7/31/22	$125,000
1R01AI127518-01A1 (Hwang PI 9/2/17-5/4/19, Randall PI 5/519-8/31/21) NIH/NIAID "Novel antiviral activity of interferon-gamma against viral replication complex" Role: Principal Investigator (20% effort)	9/2/17-8/31/21	$250,000

(c) Pending:

HONORS, PRIZES, AND AWARDS

1989	National Merit Scholar
1989	University Campus Honors Program, University of Illinois
1989	Chancellor's Scholar, University of Illinois
1992	Undergraduate Research Award, University of Illinois
1993	National Research Service Award, NIH
1994	Dean's Council, The University of Chicago
2002	American Cancer Society Postdoctoral Fellow, Rockefeller University
2006	NIH/NIDDK Digestive Disease Research Core Center Outstanding New Investigator Award, The University of Chicago
2007	Schweppe Foundation Career Development Award in Academic Medicine
2007	Herman Lopata Hepatitis C Liver Scholar, American Liver Foundation
2008	Great Lakes Regional Center for Excellence Career Development Award (NIH/NIAID)
2010	American Cancer Society Research Scholar
2011	Burroughs Wellcome Investigator in the Pathogenesis of Infectious Disease Finalist

INVITED SPEAKING

New York Academy of Sciences: Frontiers in Science. RNAi-based Analysis of Gene Function. New York, NY.
Bernard Roizman: Honoring Four Decades of Research and Teaching. Chicago, IL.
Mount Sinai School of Medicine, Department of Microbiology. New York, NY.
Northwestern University, Dept. of Microbiology and Immunology. Chicago, IL
Cleveland Clinic, Section on Microbiology. Cleveland, OH
American Society of Gene Therapy. Emerging infectious diseases as opportunities for gene therapy. Minneapolis, MN.
National Institute of Drug Abuse workshop: Use of RNAi as a HCV Therapeutic. Bethesda, MD.

12th Annual International HCV Conference. Montreal, Canada.
Rockefeller University, Center for the study of hepatitis C. New York, NY.
Alnylam Seminar Series. Cambridge, MA.
Genzyme Seminar Series. Waltham, MA.
European Association for the Study of the Liver. Barcelona, Spain.
Novartis Institute for Biomedical Research Seminar Series. Cambridge, MA.
Great Lakes Regional Center for Excellence Focus Meeting. Chicago, IL.
University of Chicago, Section on Gastroenterology. Chicago, IL.
University of Illinois, Dept. of Microbiology & Immunology. Chicago, IL.
Rosalind Franklin University, Dept. of Microbiology. North Chicago, IL.
University of Chicago, Dept. of Pathology. Chicago, IL.
Loyola University, Dept. of Microbiology & Immunology. Maywood, IL.
15th Annual International HCV Conference. Keynote address. San Antonio, TX.
University of Heidelberg, Virology Seminar Series. Heidelberg, Germany.
The University of Chicago Cancer Center. Chicago, IL
Gilead Pharmaceuticals Seminar Series. San Francisco, CA.
Great Lakes Regional Center for Excellence 6th Annual Conference. Chicago, IL.
7th Annual Howard Taylor Ricketts Symposium. Chicago, IL.
NIAID National Regional Center for Excellence Annual Meeting. Las Vegas, NV.
University of Pittsburgh, Dept. of Molecular Virology and Microbiology, Student Invited Speaker. Pittsburgh, PA
Roche Madison, Inc. Seminar Series. Madison, WI
NIAID RCE Dengue Virus Infection and Immunity. Portland, OR.
Great Lakes Regional Center for Excellence 7th Annual Conference. Chicago, IL.
Loyola University, Dept. of Microbiology & Immunology. Maywood, IL.
Rush University, Dept. of Microbiology & Immunology. Chicago, IL.
Medical College of Wisconsin, Dept. of Microbiology & Mol. Genet. Milwaukee, WI.
Mount Sinai School of Medicine, Department of Microbiology. New York, NY.
NIAID National Regional Center for Excellence Annual Meeting. Denver, CO.
Burroughs Wellcome Investigator in the Pathogenesis of Infectious Disease Advisory Board Meeting. Research Triangle Park, NC.
Infinity Pharmaceuticals Seminar Series. Cambridge, MA.
American Cancer Society Professors Meeting. Brazelton, GA.
18th Annual International HCV Conference. Scientific Session Chair. Seattle, WA.
Great Lakes Regional Center for Excellence 8th Annual Conference. Chicago, IL.
Washington University, Dept. of Microbiology. St. Louis, MO.
HEP DART 2011: Frontiers in drug development for viral hepatitis. Presenter and Scientific Session Chair. Koloa, HI.

Rochester University, Department of Microbiology. Rochester, NY.

University of Pennsylvania, Department of Microbiology. Philadelphia, PA.
Fox Chase Cancer Center. Host Defense Program. Philadelphia, PA.
Northwestern University, Dept. of Microbiology and Immunology. Chicago, IL.
FASEB Virus Assembly Meeting. Saxton's River, VT (declined due to conflict).
Great Lakes Regional Center for Excellence 9th Annual Conference. Chicago, IL.
Symposium Honoring Charles M. Rice. Rockefeller University. New York. NY
19th Annual International HCV Conference. Scientific Session Chair. Venice, Italy
Harvard University. Virology Program Seminar Series. Cambridge, MA
Harvard University. Dept. of Microbiology & Immunobiology. Cambridge, MA
(declined due to overlap).
Keystone Symposium on Positive Strand RNA Viruses. Plenary Talk. Boston, MA.
Gordon Research Conference: Viruses and Cells. Plenary Talk. Barga, Italy.
Ecole Normale Supèrieure de Lyon. Dept of Human Virology - INSERM U758. Lyon, France.
Institut Pasteur. Dept. of Virology Seminar Series. Paris, France.
University of California-San Francisco. Viral Hepatitis Minisymposium. Keynote Speaker.
San Francisco, CA
20th Annual International HCV Conference. Speaker, Scientific Session Chair. Melbourne,
Australia.
University of Washington, Dept. of Microbiology. Seattle, WA.
Duke University, Minisymposium on Human Pathogenic Viruses, Durham, NC
Bernard Roizman: Honoring Six Decades of Research & Teaching. Chicago, IL
University of Illinois, Dept. of Anatomy and Cell Biology. Chicago, IL
21st Annual International HCV Conference. Speaker. Banff, Canada
American Society for Microbiology: Biodefense & Emerging Infections. Washington DC.
Baylor University, Dept. of Molecular Virology & Microbiology. Houston, TX.
Ohio State University, Children's Research Hospital. Columbus. OH.
University of Texas Medical Branch, Infectious Disease Colloquium. Galveston, TX.
University of Alabama-Birmingham, Dept. of Microbiology. Birmingham, AL.
Northwestern University, Dept. of Microbiology & Immunology. Chicago, IL.
NIH Symposium: Metabolism & Pathogens Symposium. Rocky Mountain National Labs.
Hamilton, MT.
Nanjing International Symposium on Oncogenic Viruses & Drug Discovery. Keynote Speaker.
Nanjing, China.
Virginia Tech University, Department of Biology. Blacksburg, VA.
Northwestern University, Student invited speaker. Cellular and Molecular Basis of Disease
Symposium. Chicago, IL
University of Illinois-Chicago. Dept. of Microbiology & Immunology Seminar Series. Chicago, IL
Mount Sinai School of Medicine, Department of Microbiology. New York, NY.
Indiana University, Department of Microbiology. Bloomington, IN.
Brazilian Society for Virology, 30th Annual Meeting, Keynote Speaker, Cuiaba, Brazil

INVITED, ELECTED, OR APPOINTED EXTRAMURAL SERVICE

Peer review:

Ad hoc reviewer (54+): *Science, Cell, Cell Host & Microbe, Immunity, Molecular Cell, Cell Reports, Nature Medicine, Nature Microbiology, Nature Biotechnology, Nature Nanotechnology, Nature Reviews Microbiology, Nature Communications, Proc. Natl. Acad. Sci. USA, PLoS Biology, PLoS Pathogens, PLoS One, mBio, J. Virology, Virology, EMBO J…….*

Funding agencies (11+): *NIH*, *NSF*, *Medical Research Council, Wellcome Trust, Israeli Science Foundation, American Institute of Biological Sciences, American Cancer Society, Hong Kong*

Health Services, French National Research Agency, Agence d'Evaluation de la Recherche et des établissements d'Enseignement Supérieur, CNRS/INSERM, Czech Science Foundation

Editorial Boards

2010- Frontiers in Virology
2012- Journal of Virology
2013- Virology
2014- *PLoS Pathogens (Associate Editor)*
2015- *mSphere (Associate Editor)*

National Membership & Fellowship Training:

2003- Member, New York Academy of Sciences
2007- Member, American Society for Microbiology
2007- Mentor, American Society for Microbiology Undergraduate Research Fellowship
2010- Mentor, American Cancer Society Postdoctoral Fellowships
2012- Mentor, American Heart Association Postdoctoral Fellowship

Study Sections:

Study Sections:

2007-8 NIH/NIDDK Special Emphasis Panel ZDK1 GRB-8 M3 Study Section
2011-16 Standing Member, American Cancer Society MPC Peer Review Committee
2011 NIH/NIAID ZAI1-FDS-M Study Section
2012 NIH/NIAID ZRG1 IDM-2 (02) Study Section
2013 NIH/NIAID VIRB Study Section
2014,16 NIH/NIAID VIRA Study Section
2014 NIH/NIAID DDR Study Section
2014-15 NIH/NIAID Virology Special Emphasis Panel Study Section
2015 NIH/NIAID HCV U19 Center Study Section
2016 NIH/NIAID Zika Virus Special Emphasis Panel Study Section
2017-21 NIH/NIAID NIH VIRA standing member

Meetings:

2011- International HCV Meeting Abstract Review, Session Chair
2012 Organizer, Annual Chicago Area Virologist Association Meeting
2014 Organizer, Bernard Roizman: Honoring Five Decades of Research & Teaching
2019 Organizer, American Society for Virology Satellite Symposium: Autophagy and Viral Infection

Consulting:

2006 Alnylam
2007 Genzyme
2007 Novartis
2009 Gilead
2010 Roche Madison
2011 Infinity Pharmaceuticals
2014 Sanofi
2020 Optikira

PROFESSIONAL SOCIETIES

American Society for Microbiology

New York Academy of Sciences
American Society for Virology

EDUCATION

The College (B.A., B.S.):
Course MICR 34600/ BIOS 25286 "Viruses of Eukaryotes" for Graduate and upper-level Undergraduate Students
2006-2008
Co-instructor (course director, Drs. Evgeny Pilipenko, Tatyana Golovkina)
2 lectures (4 hours)

Graduate programs (Ph.D.):
Formal Didactic

Microbiology Seminar Series (Graduate Course)
2005-present
Co-instructor (course director, Dr. Olaf Schneewind)
2-4 lectures annually.

Course MICR 34600/ BIOS 25286 "Viruses of Eukaryotes" for Graduate and upper-level Undergraduate Students
2006-2008
Co-instructor (course director, Drs. Evgeny Pilipenko, Tatyana Golovkina)
2 lectures (4 hours)

Course PATH "Defense Mechanisms"
2008-2010
Co-instructor (course director Dr. David Boone)
3 lectures

Course BIOS 15124 Principles of Microbiology/Global Infectious Disease (course director Dr. Michaela Gack)
1 lecture

Informal

Department of Microbiology Data Club
2005-present
Participant

Randall lab meetings
2006-present
Weekly meetings designed to evaluate experimental progress and directions for trainees.

Virology Journal Club
2006-present
Weekly literature discussion and evaluation in conjunction with virology laboratories

Pritzker School of Medicine (M.D.):

Course 160-35900 "Medical Microbiology" for Medical Students

2005-2013	Co-instructor (course director, Dr. Olaf Schneewind), 9-13 lecture hours
2014-2018	Course Director, co-instructor (9 lectures).
2019-	Course Director, co-instructor (24 lectures).

Research trainees:

(a) High school students and teachers

2011	Nelson Rohrbach, New Trier High School B.S. Carleton College

(b) Undergraduate (B.A., B.S.)

2006-2009	Rosa Yoon, B.S. with honors, University of Chicago BSCD fellow, American Society for Microbiology Fellow Current: Harvard University Ph.D., Consultant- Boston Consulting Group
2010-13	Michael Tartell, B.S. with honors, University of Chicago Current: PhD program, Harvard University
2010-13	Adan Becerra, B.S. University of Chicago Current: PhD program, University of Rochester
2013-14	Olivia Yvellez, B.S., The University of Chicago Current: Research Associate, The University of Chicago
2016-18	Janet Cheung, B.S. candidate, The University of Chicago
2018-	Nikki Kasal. B.S. candidate, The University of Chicago
2020-	Jessica Oros, B.S. candidate, The University of Chicago

(c) Medical (M.D.) N/A

(d) Graduate (Ph.D.)

2007-09	Hussein Musa, MSTP Current: Anesthesiologist, South Texas Spinal Clinic
2008-2012	Nicholas Heaton, Committee on Microbiology PhD. NRSA. Nick received the William Rainey Harper Fellowship, one of The University of Chicago's highest honors, for outstanding graduate research progress and potential. Current: Assistant Professor, Duke University
2006-12	Todd Oakland, Committee on Microbiology PhD. NRSA. Master's in Public Health, Harvard University. Current: Senior Consultant, Humedica
2010-2016	Tristan Jordan, Committee on Microbiology. PhD. NRSA. NIH Diversity Supplement. Current: Postdoctoral Scholar, Ben TenOever lab, Mt. Sinai School of Medicine
2012-2017	Yasmine Baktash, Committee on Microbiology PhD. NRSA. Current: Postdoctoral Scholar, Raul Andino lab, University of California-San Francisco.
2018-2020	Kevin Furlong, Committee on Microbiology, PhD. NRSA Current: Research Speicalist, SARS-CoV-2 core, Howard T. Ricketts Regional Biocontainment Laboratory
2018-	Cathy So, Committee on Microbiology

2018- Ellen Ketter, Committee on Microbiology, NRSA

2019- Joshua Hackney, Committee on Microbiology, NRSA

Rotation students

2006 Todd Oakland (Microbiology)
Jeffrey A. Goldstein (Medical Scientist Training Program)
Hussein Musa (Medical Scientist Training Program)
Steven Mallon (Microbiology)
2007 Melissa Kane (Microbiology)
2008 Nicholas Heaton (Microbiology)
2009 Tristan Jordan (Microbiology)
2010 Sao-Mai Nguyen (Microbiology)
2012 Brian Cheng (Microbiology)
2012 Yasmine Baktash (Microbiology)
2013 Scott Biering (Microbiology)
2014 Julianna Han (Microbiology)
2016 Will Riedl (Microbiology)
2017 Taryn Serman (Microbiology)
2018 Ellen Bruner (Microbiology)
2018 Cathy So (Microbiololgy)
2018 Blake Sanders (Microbiology)
2018 Victor Mendoza (Metabolism)
2019 Joshua Hackney (Microbiology)

(e) Postdoctoral

2007-2011 Kristi Berger, Ph.D. (Univ. of Iowa)
American Cancer Society Postdoctoral Fellow
Currently: Clinical Scientist, CTM

2008-2012 Kelly Coller, Ph.D. (Northwestern Univ.)
American Cancer Society Postdoctoral Fellow
Current: Principal Scientist, Abbott Laboratories

2010-2013 Arjmund Mufti, M.D. (Univ. Of London)
Resident in NIH Gastrointestinal Training Program
Current: Assistant Professor, University of Texas Southwestern

2011-2015 Vineela Chukkapali, Ph.D. (Univ. of Michigan)
American Heart Association Postdoctoral Fellow
Current: Research Scientist, Rush University Medical School

2012-2017 Ana Shulla, Ph.D. (Loyola Univ.)
American Cancer Society Postdoctoral Fellow
Current: Research Scientist, Abbott Laboratories

2019- Natalia Peterova Ph.D. (Moscow State Univ., Russia)

2019- Chaitanya Kurhade (Umea Univ., Sweden)

2019- Soowon Kang, Ph.D. (Chung-Ang Univ, S. Korea)

2019- Shamila Sarwar, Ph.D. (Univ. of Calcutta, India)

(f) Other

2005-2008	Jacob Cooper, Research Technician. Currently: University of Washington Ph.D. program, NSF Fellow
2008-2009	Tristan Jordan Post-baccalaureate Research Education Program. Current: University of Chicago Ph.D., Mt. Sinai School of Medicine Postdoctoral Scholar
2009	Victoria Konold, Pritzker School of Medicine Experience in Research Currently: Northwestern University MD, Pediatrician- Advocate Medical Group.
2009-2010	Susana Bardina, Post-baccalaureate Research Education Program. Current: Mt. Sinai School of Medicine Ph.D. Associate Director of Development, Hexagon Bio.
2011	Yasmine Baktash, Research Technician. Current: University of Chicago Ph.D. NRSA recipient. UCSF Postdoctoral Scholar
2011-12	Fernando Davilla, Research Technician. Current: Univ. of Illinois M.D. and Anesthesiology resident.
2012-13	Kyle Haselton. Research Technician. Current: University of Illinois M.D., Resident Mayo Clinic.
2012-13	Perris Shaw, Post-baccalaureate Research Education Program. Current: Baylor University Ph.D. program
2014-15	Amani Eddins, Post-baccalaureate Research Education Program. Current: Loyola University Ph.D. program
2014-16	Anisha Madhav, Reseach Technician Current: Cedars-Sinai Ph.D. UCSD postdoctoral scholar.
2015-15	Mikal Woods, Post-baccalaureate Research Education Program. Current: University of Texas Southwestern Ph.D. program
2016-17	Arnold Olali, Post-baccalaureate Research Education Program. Current: Rush University Ph.D. program
2018-	Armando Barajas, Post-baccalaureate Research Education Program. Current: Northwestern University Ph.D. program

SERVICE

University of Chicago

Committee membership:

2006-	Committee on Microbiology
2006-	Digestive Disease Research Core Center, NIH-NIDDK
2006-	Center for Liver Disease
2006-	Trainer, 6 NIH T32 training grants
2007-	University of Chicago Comprehensive Cancer Research Center
2007-	Committee on Immunology
2012-	Global Health Initiative Committee

Service:

2005-10	Steering Committee: Host-pathogen graduate training grant
2005-	Training Committee: Graduate student admissions and recruitment

2006-	Training Committee: Committee on Microbiology curriculum evaluation
2006-08	Organizing Committee: Biomedical Sciences Cluster Retreat
2006-2007	Faculty Fundraising Group
2007-2009	Howard Taylor Ricketts Laboratory Director Search Committee
2008-	Trainer, Pritzker School of Medicine Experience in Research (PSOMER)
2008-	Trainer, Post-baccalaureate Research Education Program (PREP)
2009-	Teaching Assistants Committee
2010-	Department of Microbiology Faculty Search Committees
2010	Internal reviewer: NIH Global Health Initiative.
2011-2	Mentor, William Rainey Harper Dissertation Fellowship
2013	University of Chicago Medical Center Diversity Initiative
2013-	Pritzker Preclinical Review Committee
2015	Biological Sciences Division Best Graduate Thesis Evaluation Committee
2015-	Pritzker Medical Scientist Training Program Admissions Committee
2017-	Pritzker Initiative Steering Committee
2017-	Biological Sciences Division Diversity Council
2019-20	LCME Self-study Task Force

Leadership:

2010-	Chair, Committee on Microbiology Graduate student admissions and recruitment
2012-14	Co-chair, Department of Microbiology Faculty Search Committees
2020-	Chair, Committee on Microbiology
2020-	Director of Emerging Virus Infections (COVID-19 Core), Howard T. Ricketts Regional Biocontainment Laboratory

Other:

2006- Interview and recruit graduate, residency, MSTP, and PREP students

2006- Thesis committees:

Kelly Riordan (Microbiology), Chair
Laure Case (Microbiology), Chair
Cameron McDearmid (Microbiology)
Todd Oakland (Microbiology)
James Baugh (Microbiology)
Jonathon Budzik (Microbiology), Chair
Claire Cornelius (Microbiology)
Steve Mallon (Microbiology)
Jeff Schneider (MPMM)
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