

Lindsay N. Hayes, PhD

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Education & Employment

Assistant Professor	Dept of Cell Biology, University of Oklahoma Health Sciences Center	2023 –present
Adjunct Instructor	STEM & Computer Science Department, Clovis Community College	2022 – 2023
Research Associate	Department of Neuroscience, Johns Hopkins University	2018 – 2023
Postdoctoral Fellow	Department of Psychiatry, Johns Hopkins University Advisor: Dr. Akira Sawa, MD, PhD	2012 – 2018
Ph.D. Neuroscience	Department of Neuroscience, Brown University Advisors: Dr. Sohyun Ahn, PhD (NIH) & Dr. Mark Zervas, PhD (Brown)	2006 – 2012
B.S. Chemistry	Department of Science and Technology, Evangel University Advisor: Dr. Steve Badger, PhD	2002 – 2006

Peer-Reviewed Publications

*equal contribution, †Senior Author, #(maiden name)

1. **Hayes LN**, An K, Carloni E, Li F, Vincent E, Paranjpe M, Trippaers C, Dölen G, Goff LA, Ramos A, Kano SI, Sawa A (2022) *Prenatal immune stress blunts microglia reactivity, impairing neurocircuitry*. **Nature**. 610, 327-334. [link](#)
2. Carloni E, Ramos A, **Hayes LN**[†] (2021) *Developmental Stressors Induce Innate Immune Memory in Microglia and Contribute to Disease Risk*. **International Journal of Molecular Sciences**. 22(23), 13035. [link](#)
3. Xiao MF, Roh SE, Zhou J, Chien CC, Lucey BP, Craig MT, **Hayes LN**, Coughlin JM, Leweke FM, Jia M, Xu D, Zhou W, Talbot C, Arnold DB, Staley M, Jiang C, Reti IM, Sawa A, Pelkey KA, McBain CJ, Savonenko A, Worley P (2021) A biomarker-authenticated model of schizophrenia implicating NPTX2 loss of function. **Scientific Advances**. 26;7(48): eabf6935. [link](#)
4. Mueller FS, Richetto J, **Hayes LN**, Zambon A, Pollak D, Sawa A, Meyer U, Weber-Stadlbauer U (2019) *Influence of poly(I:C) variability on thermoregulation, immune responses and pregnancy outcomes in mouse models of maternal immune activation*. **Brain Behavior Immunity**. 80, 406-418. [link](#)
5. Fukudome D, **Hayes LN**^{*}, Faust TE^{*}, Foss CA^{*}, Kondo MA^{*}, Lee BJ, Saito A, Kano SI, Coughlin JM, Kamiya A, Pomper MG, Sawa A, Niwa M (2018) *Translocator protein (TSPO) and stress cascades in mouse models of psychosis with inflammatory disturbances*. **Schizophrenia Research**. 197, 492-497. [link](#)
6. Nucifora LG, Tanaka T, **Hayes LN**, Kim M, Lee BJ, Matsuda T, Nucifora FC, Sedlak T, Mojtabei R, Eaton WW, Sawa A (2017) *Reduction in plasma glutathione in psychosis associated with schizophrenia and bipolar disorder in translational psychiatry*. **Translational Psychiatry**. 7(8): e1215. [link](#)
7. Coughlin JM^{*}, **Hayes LN**^{*}, Tanaka T^{*}, Xiao M, Yolken RH, Worley P, Leweke FM, Sawa A (2017) *Reduced superoxide dismutase-1 (SOD1) in cerebrospinal fluid of patients with early psychosis in association with clinical features*. **Schizophrenia Research**. 183, 64-69. [link](#)
8. Tanaka T^{*}, Matsuda T^{*}, **Hayes LN**^{*}, Yang S, Rodriguez K, Severance EG, Yolken RH, Sawa A, Eaton WW (2017) *Infection and inflammation in schizophrenia and bipolar disorder*. **Neuroscience Research**. 115, 59-63. [link](#)
9. **Hayes LN**^{*}, Shevelkin A^{*}, Zeldon M, Steel G, Chen PL, Obie C, Pulver A, Avramopoulos D, Valle D, Sawa A^{*}, Pletnikov MV^{*} (2016) *Neuregulin 3 knockout mice exhibit behaviors consistent with psychotic disorders*. **Molecular Neuropsychiatry**. 2(2), 79-87. [link](#)

10. Coughlin JM, Wang Y, Ambinder EB, Ward RE, Minn I, Vranesic M, Kim PK, Ford CN, Higgs C, **Hayes LN**, Schretlen DJ, Dannals RF, Kassiou M, Sawa A, Pomper MG (2016) *In vivo markers of inflammatory response in recent-onset schizophrenia: a combined study using [(11)C]DPA-713 PET and analysis of CSF and plasma.* **Translational Psychiatry.** 6, e777. [link](#)
11. **Hayes LN**, Severance EG, Leek JT, Gressitt KL, Rohleder C, Coughlin JM, Leweke FM, Yolken RH, Sawa A (2014) *Inflammatory molecular signature associated with infectious agents in psychosis.* **Schizophrenia Bulletin.** 40(5), 963-972. [link](#)
12. **Hayes L**, Ralls S, Wang H, Ahn S (2013) *Duration of Shh signaling contributes to mDA neuron diversity.* **Developmental Biology.** 374:1, 115-126. [link](#)
13. **Hayes L**, Zhang Z, Albert P, Zervas M, Ahn S (2011) *The Timing of Sonic Hedgehog and Gli1 Expression Segregates Midbrain Dopamine Neurons.* **Journal of Comparative Neurology.** 519:15, 3001-3018. [link](#)
14. Brown A, Machan JT, **Hayes L**, Zervas M (2011) *Molecular organization and timing of Wnt1 expression define cohorts of midbrain dopamine neuron progenitors in vivo.* **Journal of Comparative Neurology.** 519:15, 2978-3000. [link](#)
15. Carney R, Mangin JM, **Hayes L**, Mansfield K, Sousa V, Gord F, Machold R, Ahn S, Gallo V, Corbin J (2010) *Sonic hedgehog expressing and responding cells generate neuronal diversity in the medial amygdala.* **Neural Development.** 5:14. [link](#)
16. Devore M, **Foresee L**[#], Michno N, Badger S (2006) *Determination of Environmental Conditions of Four Greene County Caves.* **Transactions of the Missouri Academy of Science.** 40, 22-29.
17. Li K, **Foresee LN**[#], Tunge JA (2005) *Trifluoroacetic Acid-Mediated Hydroarylation: Synthesis of Dihydrocoumarins and Dihydroquinolones.* **Journal of Organic Chemistry.** 70, 2881-2883. [link](#)
18. Tunge JA, **Foresee LN**[#] (2005) *Mechanistic Studies of Fujiwara Hydroarylation. C-H Activation versus Electrophilic Aromatic Substitution.* **Organometallics.** 24(26), 6440-6444. [link](#)

Pre-prints/ Manuscripts under review

1. Ramos A, Ishizuka K, Namkung H, **Hayes LN**, Saito A, Sengupta A, Srivastava R, Calva C, Hayashida A, Elkins N, Palen T, Carloni E, Tsujimura T, Gallego JA, Robinson DG, Malhotra AK, Ikemoto S, Rais R, Slusher BS, Niwa M, Saitoh T, Takimoto E, Sawa A (2022) *The nuclear GAPDH-HMBG cascade in cortical microglia regulates cognitive flexibility.* **bioRxiv.** 2022.06.21.497065 doi:10.1101/2022.06.21.497065. [link](#)
2. **Hayes LN**, An K, Carloni E, Li F, Vincent E, Paranjpe M, Dölen G, Goff LA, Ramos A, Kano SI, Sawa A (2021) *Prenatal immune stress induces a prolonged blunting of microglia activation and impacts striatal connectivity.* **bioRxiv.** 2021.12.27.473694 doi:10.1101/2021.12.27.473694. [link](#)

Professional and Organizational Activities

Funding

Center for Advancement of HIV Neurotherapeutics (PI: Hayes), NIMH/JHU 08/2022
P30MH075673-17 subaward
Title: Persistent HIV viral transcripts in brain-derived immune cells in NeuroHIV

Center for Novel Therapeutics for HIV-Associated Cognitive Disorders (PI: Hayes), NIMH/JHU 07/2021
P30MH075673-15 subaward
Title: Isolation of brain-derived myeloid cells in NeuroHIV

Awards & Honors

ACNP Travel Award, American College of Neuropsychopharmacology (ACNP) 2023

Travel Award, 6 th Annual NIH Graduate Student Research Symposium	2009
Travel Award, Brown & NIH Joint Retreat	2009
Summa Cum Laude Graduate, Evangel University	2006
Research Fellow, Dept. of Science and Technology, Evangel University	2005 – 2006
NSF-REU Award, Dept. of Chemistry, Loyola University	2005
NSE-REU Award, Dept. of Chemistry, University of Kansas	2004

Recognition & Distinction

Highlights of Hayes et al. 2022

Blank, T., Prinz, M. 2023. *Objection non-responsive! How maternal immune activation in pregnancy weakens subsequent microglial immune response.* **Cell Research** 33, 193–194

Flemming, A. 2022. *Effect of prenatal stress on the developing brain.* **Nature Review Immunology** 22, 655

Traetta ME, Tremblay MÈ. 2022. *Prenatal inflammation shapes microglial immune response into adulthood.* **Trends in Immunology** 2022 Dec;43(12):953-955

Media Releases or Interviews

Contributed Interview: The next hot topic in autism research? Immune cells	11/16/2014
Media Release: A Blood Pressure Hormone Implicated in Psychosis	11/19/2014
Media Release: CSF Biomarkers Studied as Factors to Predict Schizophrenia Onset	6/2/2014

Professional Committees

Reviewer, Discovery Grant Award, Johns Hopkins University	2023
Member, Organizing Committee, Schizophrenia Center Monthly Seminar Series	2021 – 2023
Reviewer, Admissions Committee, JHU Psychiatry Summer Research Program	2012 – 2014
Reviewer, Admissions Committee, Brown- NIH Graduate Partnership Program	2010 – 2011
Organizer, Brown Graduate Partnership Program Seminar Series	2008 – 2011
Member, Organizing Committee, Annual NIH Graduate Student Retreat	2008

Professional Affiliations

Member, Society for Neuroscience	2007-present
Presenter & Organizer of Mini-Symposium for 2023 Society for Neuroscience Annual Meeting	

Ad-hoc Reviewer

Lancet
 Neuropsychopharmacology
 Neuropsychopharmacology Reviews
 Science Advances
 Translational Psychiatry
 Schizophrenia Bulletin
 Schizophrenia Research
 Brain Behavior Research
 Experimental Neurology
 Frontiers in Neuroscience

Conferences

Conference Session Chair/Co-Chair

American College of Neuropsychopharmacology (ACNP): Glial & Immune Cells Contribute to Brain Function in Neuropsychiatric Disorder	12/4/2023
Spring Brain Conference: Plenary Session 10: Trainee Presentations and Hot Topics	4/26/2023
Keystone Symposia: Neuro-Immune Interactions in the Central Nervous System Workshop 3: Immunotherapy of Neurodegeneration	6/9/2022

Invited Speaker/Symposium Speaker

5/25/2024	Presenter, Federation of European Neuroscience Societies (FENS), Vienna, Austria "Maternal immune activation and neurodevelopmental disorders: from molecular insights to new models"
12/5/2023	Presenter and Session Chair, American College of Neuropsychopharmacology (ACNP), Tampa, FL "Glial & Immune Cells Contribute to Brain Function in Neuropsychiatric Disorders"
10/13/2023	Presenter, Society for Neuroscience (SfN) Mini-symposium, Washington, DC "The good, the bad, and the microglia: How microglia shape brain circuitry across the lifespan"
4/24/2023	Presenter and Session Chair, Spring Brain Conference, Sedona, AZ "Prenatal stress induces diminished microglia reactivity and deficits in striatal connectivity"
11/10/2022	Open Box Science Virtual Seminar (link) "Prenatal immune stress blunts microglia reactivity, impairing neurocircuitry"
10/7/2022	Johns Hopkins University, Molecular and Comparative Pathobiology Departmental Seminar "Microglia Contributions to Immune Mechanisms in Psychosis"
6/13/2022	CSHL Workshop, Schizophrenia and Related Disorders, Cold Spring Harbor, NY "Microglia Contributions to Immune Mechanisms in Psychosis"
7/23/2019	Johns Hopkins Perinatology & Neonatology Monthly Colloquium. " <i>Neuroimmune Interactions from Development to Mature Brain Function</i> "
11/28/2016	The 22 nd Annual Stanley Meeting, Baltimore, MD " <i>Maternal Stress Alters Microglia Responsiveness: Influence on Brain Function and Behavior</i> "

Abstract selected for Oral Presentations (speaker in bold)

1. **Hayes LN**, An K, Carloni E, Li F, Vincent E, Paranjpe M, Trippaers C, Dölen G, Goff LA, Ramos A, Kano SI, Sawa A. (2022) Prenatal immune stress induces a prolonged blunting of microglia reactivity that impairs striatal connectivity. Keystone Symposia: Neuro-Immune Interactions in the Central Nervous System.
2. **Hayes LN**, An K, Vincent E, Paranjpe M, Bless L, Chang AJ, Diaz C, Dölen G, Kano SI, Ramos A, Goff LA, Sawa A (2021) Prenatal immune stress induces a prolonged blunting of microglia activation and neuronal connectivity. EMBO Microglia Workshop (Flash Talk)
3. **Hayes LN**, An K, Vincent E, Paranjpe M, Bless L, Chang AJ, Diaz C, Dölen G, Kano SI, Ramos A, Goff LA, Sawa A (2019) Prenatal immune stress induces a prolonged blunting of microglia activation and impacts social behavior and neuronal connectivity. Glia Biology: Functional Interactions Among Glia and Neurons Gordon Research Seminar
4. **Hayes LN**, An K, Vincent E, Paranjpe M, Kim M, Chang AJ, Diaz C, Ramos A, Goff LA, Sawa A (2018) Early maternal stress diminishes microglia reactivity and striatum connectivity. Baltimore Brain Series October 30, 2018

5. **Hayes LN**, An K, Paranjpe M, Kim M, Vincent E, Goff LA, Sawa A (2018) Early Maternal Stress Alters Microglia Responsiveness to Activation and Impacts Striatal Circuit Function and Behaviors. EMBO Microglia Workshop
6. **Hayes LN**, An K, Barodia S, Moore J, Kim S-H, Jaaro-Peled H, Fukudome D, Faust T, Niwa M, Sawa A. (2015) Alterations in adolescent stress cascades in genetic and environmental mouse models of major mental illness and the implications on adult behavioral deficits. Society for Neuroscience Meeting
7. Coughlin JM, Tanaka T, Ford CN, Kim PK, **Hayes LN**, Marsman A, Barker PB, Sawa A. (2015) Alterations in markers associated with oxidative stress, inflammation, and protein misfolding in patients with recent onset psychosis. Society for Biological Psychiatry
8. **Hayes LN**, Sawa A. (2015) Angiotensin Signaling in Development and Pathology of Immune- Associated Psychosis. International Congress on Schizophrenia Research
9. **Hayes LN**, Sawa A. (2014) Inflammation in schizophrenia patients and maternal immune activation new insights from the angiotensin pathway. Neuroscience Department Lecture Series
10. **Hayes LN**, Sawa A. (2014) Angiotensin signaling as a key regulator of neuroinflammation: a role in developmental psychotic disease. Society for Neuroscience Meeting
11. **Hayes LN**, Alkhunaizi F, Sawa A. (2013) Molecular and cellular characterization of microglia- like cells derived from patients with schizophrenia and their implications for the developmental insult hypothesis. Society for Neuroscience
12. **Hayes LN**, Zhang Z, Albert P, Zervas M, Ahn S. (2011). The Timing of Sonic Hedgehog and Gli1 Expression Segregates Midbrain Dopamine Neurons. Keystone Symposium: Neurodegenerative Diseases
13. **Hayes LN**, Ahn S. (2010) Where does dopamine neuron diversity come from? NICHD Principal Investigator Retreat
14. **Hayes LN**, Ahn S. (2009) Not all dopamine neurons are alike: How early Sonic Hedgehog signaling may influence later diversity. NIH Neurobiology Interest Group

Poster Presentations

1. **Hayes LN**, An K, Carloni E, Li F, Vincent E, Paranjpe M, Dölen G, Goff LA, Ramos A, Kano S, Sawa A. (2022) *Prenatal immune stress blunts microglia reactivity which impairs neurocircuitry.* Cold Spring Harbor Glia in Health and Disease
2. **Hayes LN**, An K, Vincent E, Paranjpe M, Kim M, Chang AJ, Diaz C, Ramos A, Goff LA, Sawa A. (2018) *Early maternal stress diminishes microglia reactivity and striatum connectivity.* Glia-Neuron Interaction in Developing Circuits Rockefeller University
3. **Hayes LN**, An K, Kim M, Nardou R, Chang AJ, Dolen G, Sawa A. (2017) *Microglia priming through maternal immune stress influences brain function and behavior.* Society for Neuroscience
4. Nucifora LG, Tanaka T, **Hayes LN**, Kim M, Lee BJ, Matsudo T, Nucifora FC, Sedlak T, Mojtabai R, Eaton W, Sawa A. (2017) *Reduction of plasma glutathione in psychosis associated with schizophrenia and bipolar disorder in translational psychiatry.* Society for Neuroscience
5. **Hayes LN**, An K, Vincent E, Paranjpe M, Nardou R, Kim M, Dolen G, Goff LA, Sawa A. (2017) *Microglia priming by early maternal stress diminishes immune responsiveness and task switching.* Neuro-Immune Axis: Reciprocal Regulation in Development, Health, and Disease Cell Symposia
6. **Hayes LN**, Diaz C, Nardou R, Chang A, Dolen G, Sawa A. (2016) *Developmental deficits in microglia influence brain function and behavior.* Keystone Symposia: Microglia in the Brain
7. Niwa M, **Hayes LN**, Tanaka T, Faust T, Fukudome D, Cash-Padgett T, Jaaro-Peled H. (2015) *Oxidative Stress in the Pathophysiology of Psychiatric Disorders: Studies of Patient Biospecimens and Animal Models.* ACNP 54th Annual Meeting
8. Coughlin JM, Wang Y, Tanaka T, Ma S, **Hayes LN**, Pomper MG, Sawa A. (2014) *Probing molecular markers of inflammation and oxidative stress in patients with early stage schizophrenia: A combined study of CSF and PET-based imaging.* ACNP 53rd Annual Meeting

9. **Hayes LN**, Kim J, Sawa A. (2014) *Angiotensin signaling in schizophrenia patients and mice after maternal immune activation: Potential molecular regulator of neuroinflammation*. Cold Spring Harbor Glia in Health and Disease
10. **Hayes LN**, Zervas M, Ahn S. (2011) *The progenitors in the ventral mesencephalon mutually regulate the induction and cessation of Shh and Gli1 expression for proper dopamine neuron specification*. Society for Neuroscience Meeting
11. **Hayes LN**, Zervas M, Ahn S. (2009) *Linking the Shh and Gli1 lineages to dopamine neuron diversity: Discovering how the subtypes and circuits are established in the adult*. Society for Neuroscience Meeting
12. Carney R, **Hayes LN**, Sousa V, Mansfield K, Fishell G, Machold R, Ahn S, Corbin, J. (2009) *Genetic specification of neuronal diversity in the medial amygdala*. Society for Neuroscience Meeting
13. **Hayes LN**, Zervas M, Ahn S. (2008) *Sonic hedgehog signaling contributes to midbrain dopamine neuron development*. Society for Neuroscience Meeting

Teaching & Mentoring Activities

Teaching & Guest Lecturing

Co-Instructor , Practical Genomics Workshop, JHU	2023
Co-Instructor , Research in Biology (Biol-12), Clovis Community College	2021-present
Lead Teaching Assistant , Practical Genomics Workshop, JHU	2021
Instructor , Neuroscience: A Single Cell Story, JHU Winter 2020 Intersession	2020
Teaching Assistant , Practical Genomics Workshop, JHU	2019
Guest Lecturer , Lunch-n-Learn Seminar Series, JHU Psychiatry Training Program	2016
Keynote Speaker , STEM Honors Conference, Ozarks Technical Community College	2014
Guest Lecturer , Chemistry for Health Sciences, Evangel University	2006
Teaching Assistant , General and Organic Chemistry, Evangel University	2003-2006

Mentorship (14 mentees)

Supervisor of Graduate Student Training

Ruoyu (James) Wang, Master's Rotation Student	2023
Chloë Trippaers, <i>Visiting Graduate Fellow</i> , co-author on 1 publication	2021 – 2022
Amedeo Primerano MD, <i>Visiting Medical Fellow</i>	2015
Anna J. Chang, PhD, <i>JHU Rotation Graduate Student</i>	2013

Supervisor for Research Technicians

Elisa Carloni, <i>post-baccalaureate student</i> , co-author on 2 publications	2019 – 2021
Fangze Li, <i>post-baccalaureate student</i> , co-author on 1 publication	2019 – 2021

Supervisor for Undergraduates in Summer Research Programs

Taechawidd (Phillip) Nantawisarakul, <i>PSTAR Summer Student</i>	2015
Carolyn Diaz, <i>PSTAR Summer Student</i>	2013
Molly Pfeifer, DVM, <i>NIH Summer Student</i>	2010

Supervisor of Undergraduate Student Training

Rajaa Alhamd, <i>JHU Undergraduate</i>	2023
Lena Bless, <i>JHU Undergraduate</i>	2017 – 2018
Manish Paranjpe, <i>JHU Undergraduate</i> , co-author on 1 publication	2017 – 2018
Minjung Kim, <i>JHU Undergraduate</i> , co-author on 1 publication	2015 – 2017
Fatimah Alkhunaizi, MD, <i>JHU Undergraduate</i>	2012 – 2013

Outreach Activities

Co-Instructor, Research in Biology (virtual), Clovis Community College 2021 – 2022

Course-based Undergraduate Research Experience

Students were primarily Hispanic and/or first-generation college students. Course provides technical and practical skills to prepare students for funded research internships.

Lecturer, Lunch-n-Learn Seminar Series, JHU, Psychiatry Summer Training and Research 2016

Clinical and Basic Science Career Development and Research Trajectories

Students were from teaching universities with less access to research opportunities. Program provided research opportunities, clinical shadowing, and career development mentorship.

Keynote speaker, STEM Honors Conference, Ozarks Technical Community College 2014

Research Opportunities for Community College STEM Students

Students were from low socioeconomic environments and/or first-generation college students. Symposium highlighted trajectories into STEM careers and identify research opportunities.