

David H. Root, Ph.D.
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[Google Scholar Profile](#)
h-index: 22; i10-index: 25

University of Colorado, Boulder
Department of Psychology and Neuroscience
Assistant Professor
Boettcher Investigator 2018-present

Education:

Rutgers University, Piscataway, NJ 2012
Ph.D., Psychology (Behavioral Neuroscience)

Seton Hall University, South Orange, NJ 2006
M.S., Experimental Psychology (Behavioral Neuroscience)

Western New England College, Springfield, MA 2004
B.S., Psychology (Mathematics)

Research Experience:

National Institute on Drug Abuse, Baltimore, MD 2012-2017
Postdoctoral Fellow – PI: Marisela Morales

Rutgers University, Piscataway, NJ 2007-2012
Pre-doctoral student – PI: Mark O. West

Seton Hall University, South Orange, NJ 2004-2006
Pre-master's student – PI: Michael Vigorito

Western New England College, Springfield, MA 2003-2004
Pre-bachelor's student – PI: Sheralee Tershner

Active Grants:

R01, National Institute on Drug Abuse. PI: Root 2020-2025

NARSAD Young Investigator Award, Brain & Behavior Research Foundation. PI: Root 2020-2022

Webb-Waring Biomedical Research Award, Boettcher Foundation. PI: Root 2018-2022

RIO Seed Grant. University of Colorado. PI: Root 2021-2022

ABnexus. University of Colorado. Pls: Root & Ford

2022

Inactive Grants:

CO-Pilot, Colorado Clinical and Translational Sciences Institute. PI: Root

2019-2020

F31, National Institute on Drug Abuse (DA 026252)

2009-2012

T32, National Institute on Mental Health (MH 019957)

2007

Awards:

Outstanding Faculty Mentor
University of Colorado Graduate School

2021

Mentor Award Honorable Mention
University of Colorado UROP

2021

Conan Kornetsky Fellow
Winter Conference on Brain Research

2020

Boettcher Investigator
Boettcher Foundation

2018

NIH Summer Mentor Award
National Institutes of Health

2015, 2016, 2017

Special Poster Session
Winter Conference on Brain Research

2014 & 2015

Fellows Award in Research Excellence
National Institutes of Health

2013

Travel Award
Motivational Neuronal Networks Conference

2010

Young Investigator Award
Society on NeuroImmune Pharmacology

2006

Teaching Experience:

NRSC 5100 Introduction to Neuroscience I
University of Colorado

Fall 2020

NRSC 5110 Introduction to Neuroscience II – One lecture
University of Colorado

2019-present

NRSC 5100 Introduction to Neuroscience I – One lecture
University of Colorado

2018-present

NRSC 4032 Neurobiology of Learning and Memory - Lecturer
University of Colorado

2019-present

NRSC 4841 Independent Study in Neuroscience
University of Colorado

2019-present

NRSC 6841 Neuroscience Ph.D. Breadth requirement - Lecturer
University of Colorado

2018-present

NRSC 7102 Topics in Neuroscience: Modern Neuroscience Methods – Creator, Lecturer
University of Colorado

2018-present

Methods of Neuroscience - Co-creator, Lecturer
National Institute on Drug Abuse

2015-2016

Mentoring/Advising:

Doctoral Student Mentor

Dillon McGovern (CU Boulder: Neuroscience)

Annie Ly (CU Boulder: Neuroscience)

Dissertation Committee:

Florencia Bercum

Julie Sadino

Dillon McGovern

Sarah Zych (Anschutz)

Nicholas Beacher (Rutgers)

Comprehensive Review Committee:

Dillon McGovern

Annie Ly

Katherine Stansfield

Anne Pierce

Kathleen Murphy

Gabriel Costanza

Graduate Independent Study Committee (breadth requirement):

Annie Ly

Dillon McGovern

Anne Pierce

Jayson Ball

Gabriel Costanza

Undergraduate Independent Study Mentor:

Paul Rastrelli (Boettcher)

Arielle Sandoval (Boettcher)

Steven Oakes (Boettcher)

Louis Nunez (McNair)

Declan Mulcahy (undergraduate)

Alex Barker (undergraduate)

Bryce Poirot (undergraduate)

Will Plantz (undergraduate)

Sarah Bates (undergraduate)

Soo Lee (undergraduate)

Kyu Ro (undergraduate)

Sophie Elvig (undergraduate)

Hadley Mills (BSI)

David Huynh (BSI)

Felix Gonzalez (SMART)

Makaila Banks (SMART)

Katelynn Fegan (senior thesis)

Sponsored Undergraduate Fellowship Mentor:

Rocio Monroy-Tello – McNair
Makaila Banks – McNair
Kyu Ro – McNair
Louis Nunez – McNair
Kyu Ro – UROP (twice)
Soo (Janet) Lee – UROP (twice)
Will Plantz – UROP
Kris Lauridsen – UROP
Katelynn Fegan – UROP (declined)
Hadley Mills – BSI
David Huynh – BSI
Felix Gonzalez – SMART
Makaila Banks – SMART
Bridges to Baccalaureate – Devan McMillan
Regis University Externship – Vivianne Benbrook
Paul Rastrelli - Boettcher
Arielle Sandoval - Boettcher
Steven Oakes - Boettcher

Undergraduate Honors Thesis Advisor:

Katelynn Fegan (summa cum laude)
Alex Barker (ongoing)
Declan Mulcahy (ongoing)
William Plantz (ongoing)

Undergraduate Honors Thesis Committee:

Conor Kelly (*summa cum laude*)
Emma Burt (*summa cum laude*)
Valerie Olsen (*magna cum laude*)
Kelsey Harbert (*magna cum laude*)
Colton Paterson (*magna cum laude*)
Shaan Sharma (*cum laude*)
Caitlin (Aryanna) Ryan (*summa cum laude*)
Katelynn Hughes (*summa cum laude*)
Troy Arthur (*cum laude*)
Jack Lovell (*cum laude*)
Garrett Potter (ongoing)
Ashley Pak (ongoing)
Anushka Thummalapenta (ongoing)

Service:

Ad hoc Journals: Neuron, Biological Psychiatry, Neuropsychopharmacology, Journal of Neuroscience, eNeuro, Brain Structure & Function, European Journal of Neuroscience, Behavioural Brain Research, Schizophrenia Bulletin, Neurobiology of Learning and Memory, Experimental Neurology, Physiology & Behavior, Addiction Biology, Neuropharmacology, Acta Physiologica, Journal of Visualized Experiments, Communications Biology, Neural Regeneration Research, Frontiers in Psychiatry, Molecular Neurodegeneration, Neuroscience Letters.

Grant Review:

Boettcher Scholars	2021
Anschutz Boulder Nexus	2020
RIO Fay/Frank	2020
NSF GRFP	2020-2021

United States-Israel Binational Science Foundation
 French National Research Agency
 Czech Science Foundation

2018
 2013-2015
 2013

Journals:

* denotes senior/corresponding author as CU Boulder faculty

denotes author as CU Boulder faculty but not senior/corresponding author

Ly A, **Root DH***. (2021). Neuromedin U: a neuropeptide modulator of GABA transmission contributes to cocaine seeking. *Neuropsychopharmacology*

Lauridsen K*, Ly A*, Prevost ED, McNulty C, McGovern DJ, Tay JW, Dragavon J, **Root DH***. (2021). A semi-automated workflow for brain Slice Histology Alignment, Registration, and Cell Quantification (SHARCQ). In revision

McGovern DJ, Ecton KL, Huynh DT, Rau AR, Hentges ST, Ly A, Baratta MV*, **Root DH***. (2021). Ventral tegmental area glutamate neurons mediate the nonassociative consequences of traumatic stress. [bioRxiv. In revision](#)

McGovern DJ, Polter AM, **Root DH***. (2019). Neurochemical signaling of reward and aversion to ventral tegmental area glutamate neurons. *Journal of Neuroscience* 41(25):5471-5486. [Pubmed](#)

Root DH#, Barker DJ, Estrin DJ, Miranda-Barrientos JA, Liu B, Zhang S, Wang HL, Vautier F, Ramakrishnan C, Kim YS, Fenno L, Deisseroth K, Morales M. (2020). Distinct Signaling by Ventral Tegmental Area Glutamate, GABA, and Combinatorial Glutamate-GABA Neurons in Motivated Behavior. *Cell Reports* 32(9):108094. [Pubmed](#)

McGovern DJ, **Root DH***. (2019). Ventral pallidum: a promising target for addiction intervention. *Neuropsychopharmacology*, 44:2151-2152. [Pubmed](#)

Phillips AG, McGovern DJ, Lee S, Ro K, Huynh DT, Elvig SK, Fegan KN, **Root DH***. (2020). Oral prescription opioid-seeking behavior in male and female mice. *Addiction Biology* 25(6):e12828. [Pubmed](#)

Root DH, Zhang S, Barker DJ, Miranda-Barrientos J, Liu B, Wang H-L, Morales M. (2018b). Selective brain distribution and distinctive synaptic architecture of dual glutamatergic-GABAergic neurons. *Cell Reports*, 23(12):3465-3479. PMID: 29924991. [Pubmed](#)

- NIDA “Featured” Paper – November 2018

Root DH#, Estrin DJ, Morales M. (2018a). Aversion or salience signaling by ventral tegmental area glutamate neurons. *iScience*, 2:51-62. [Pubmed](#)

Barker DJ, Miranda-Barrientos J, Zhang S, **Root DH**, Wang H-L, Liu B, Calipari ES, Morales M. (2017). Lateral preoptic area exhibits divergent control of the lateral habenula. *Cell Reports*, 21(7):1757-1769. [Pubmed](#)

- NIDA “Featured” Paper – April 2018

Zahm DS & **Root DH**. (2017). Review of the cytology and connections of the lateral habenula, an avatar of adaptive behaving. *Pharmacology, Biochemistry and Behavior*, 162:3-21. [Pubmed](#)

Root DH, Wang HL, Liu B, Barker DJ, Mod L, Szocsics P, Silva AC, Magloczky Z, Morales M. (2016). Glutamate neurons are intermixed with midbrain dopamine neurons in nonhuman primates and humans. *Scientific Reports*, 6:30615. [Pubmed](#)

- NIDA “Featured” Paper – December 2016

Barker DJ, **Root DH**, Zhang S, Morales M. (2016). Multiplexed Neurochemical Signaling in the Ventral Tegmental Area : Glutamatergic, GABAergic, and Dopaminergic Partnerships. *Journal of Chemical*

Neuroanatomy, 73:33-42. [Pubmed](#)

- NIDA “Reviews to Read” – July 2016

Barker DJ, Striano BM, Coffey KC, **Root DH**, Pawlak AP, Kim OA, Kulik J, Fabbriatore AT, West MO. (2015). Sensitivity to self-administered cocaine within the lateral preoptic-rostral lateral hypothalamic continuum. *Brain Structure & Function*, 220(3):1841-1854. [Pubmed](#)

Root DH, Zaborszky L, Melendez RI, Napier TC. (2015b). The ventral pallidum: Subregion-specific functional anatomy and roles in motivated behaviors. *Progress in Neurobiology*, 130:29-70. [Pubmed](#)

Root DH, Hoffman AF, Good CH, Zhang S, Gigante ED, Lupica CR, Morales M. (2015a). Norepinephrine activates dopamine D4 receptors in the rat lateral habenula. *Journal of Neuroscience*, 35(8):3460-3469. [Pubmed](#)

- NIDA “Featured” Paper – August 2015

Root DH, Mejias-Aponte CA, Zhang S, Wang HL, Hoffman AF, Lupica CR, Morales M. (2014b). Single mesohabenular axons release both glutamate and GABA. *Nature Neuroscience* 17(11):1429-1622. [Pubmed](#)

- NIDA “Hot” Paper – November 2014
- Nature Neuroscience Featured Paper
- Research Highlight, Yates D (2014) Nature Neuroscience Reviews 15:700-701
- News and Views, Uchida N (2014) Nature Neuroscience 17:1432-1434

Root DH, Mejias-Aponte CA, Qi J, Morales M. (2014a). Role of glutamatergic projections from ventral tegmental area to lateral habenula in aversive conditioning. *Journal of Neuroscience*, 34(42):13906-13910. [Pubmed](#)

Striano BM, Barker DJ, Pawlak AP, **Root DH**, Fabbriatore AT, Coffey KC, Stamos JP, West MO. (2014). Olfactory tubercle neurons exhibit slow-phasic firing patterns during cocaine self-administration. *Synapse*, 68(7):321-323. [Pubmed](#)

Morales M & **Root DH**. (2014). Glutamate neurons within the midbrain dopamine regions. *Neuroscience* 282:60-68. [Pubmed](#)

Root DH. (2013b). The ventromedial ventral pallidum subregion is necessary for outcome-specific Pavlovian-Instrumental Transfer. *Journal of Neuroscience*, 33(48):18707-18709. [Pubmed](#)

Barker DJ, Simmons SJ, Servilio LC, Bercovicz D, Ma S, **Root DH**, Pawlak AP, West MO. (2014). Ultrasonic Vocalizations: evidence for an affective opponent process during cocaine self-administration. *Psychopharmacology*, 231(5):909-918. [Pubmed](#)

- Featured in The Daily Record, The Examiner, RutgersNews

Coffey KR, Diamond A, Barker DJ, Ma S, **Root DH**, West MO. (2014). A Procedure for Implanting Organized Arrays of Microwires for Single-Unit Recordings in Awake, Behaving Animals, *Journal of Visualized Experiments*, 84:e51004. [Pubmed](#)

Barker DJ, Bercovicz D, Servilio LC, Simmons SJ, Ma S, **Root DH**, Pawlak AP, West MO. (2014). Rat Ultrasonic Vocalizations Demonstrate that the Motivation to Contextually Reinstate Drug-Seeking Behavior does not Necessarily Involve a Hedonic Response. *Addiction Biology*, 19(5):781-790. [Pubmed](#)

Ma S, Pawlak AP, Cho J, **Root DH**, Barker DJ, West MO. (2013). Amphetamine’s dose-dependent effects on dorsolateral striatum sensorimotor neuron firing. *Behavioural Brain Research*, 244:152-161. [Pubmed](#)

Coffey KR, Barker DJ, Ma S, **Root DH**, Martinez L, Horvitz JC, West MO (2013). Effects of Varying Reinforcement Probability on Pavlovian Approach Behavior and Ultrasonic Vocalizations in Rats. *Behavioural Brain Research*, 237:256-262. [Pubmed](#)

Root DH, Ma S, Barker DJ, Megehee L, Striano BM, Ralston CM, Fabbriatore AT, West MO. (2013a). Differential roles of ventral pallidum subregions during cocaine self-administration behaviors. *J Comp Neurol*, 521(3):558-588. [Pubmed](#)

Root DH, Fabbriatore AT, Pawlak AP, Barker DJ, Ma S, West MO. (2012). Slow phasic and tonic activity of ventral pallidal neurons during cocaine self-administration. *Synapse*, 66(2):106-127. [Pubmed](#)

McGinty VB, Hayden BY, Heilbronner ST, Dumont EC, Graves SM, Mirrione MM, du Hoffman J, Sartor GC, Espana RA, Millan EZ, Difeliceantonio AG, Marchant NJ, Napier, TC, **Root DH**, Borgland SL, Treadway MT, Floresco SB, McGinty JF, Haber S. (2011). The Reward Circuit: Emerging, Reemerging, and Forgotten Brain Areas: Notes from the 2010 Motivational and Neural Networks Conference. *Behavioural Brain Research*, 225(1):348-357. [Pubmed](#)

Root DH, Barker DJ, Ma S, Coffee KR, West MO. (2011). Evidence for skilled cocaine self-administration in rats. *Psychopharmacology*, 217(1):91-100. [Pubmed](#)

Barker DJ, **Root DH**, Ma S, Jha S, Megehee L, Pawlak AP, West MO. (2010). Dose dependent differences in short ultrasonic vocalizations emitted by rats during cocaine self-administration. *Psychopharmacology*, 211:435-442. [Pubmed](#)

Root DH, Tang CC, Ma S, Pawlak AP, West MO. (2010b). Absence of cue-evoked firing in rat dorsolateral striatum neurons. *Behavioural Brain Research*, 211(1):23-32. [Pubmed](#)

Root DH, Fabbriatore AT, Ma S, Barker DJ, West MO. (2010a). Rapid phasic activity of ventral pallidal neurons during cocaine self-administration. *Synapse*, 64(9):704-713. [Pubmed](#)

- [Faculty of 1000 Biology Comment](#), 23 Apr 2010

Tang CC, **Root DH**, Duke DC, Zhu Y, Teixeira K, Ma S, Barker DJ, West MO. (2009). Decreased firing of striatal neurons related to licking during acquisition and overtraining of a licking task. *Journal of Neuroscience*, 29(44):13952-13961. [Pubmed](#)

Root DH, Fabbriatore AT, Barker DJ, Ma S, Pawlak AP, West MO. (2009b). Evidence for habitual and goal-directed behavior following devaluation of cocaine: a multifaceted interpretation of relapse. *PLoS One*, 4(9):e7170. [Pubmed](#)

Root DH, Barker DJ, Ma S. (2009a). Duality of salience in dopamine neurons. *Proceedings of the National Academy of Sciences*, 106(12):E84. [Pubmed](#)

Silvestri AJ & **Root DH**. (2008). Effects of REM Deprivation and an NMDA Agonist on the Extinction of Conditioned Fear. *Physiology & Behavior*, 93:274-281. [Pubmed](#)

Book chapters

Root DH, West MO. (2013). Neural Mechanisms of Learning: Animal Models of Cocaine Addiction. In: [Biological Research on Addiction: Comprehensive Addictive Behaviors and Disorders](#). Elsevier Inc., San Diego: Academic Press, pp. 315–322. [Google Books](#).

Invited Talks

Office of Animal Research	2021
CU Sleep and Circadian Summer School	2021
Neuroscience program (Anschutz)	2020
Winter Brain (Chair, Circuits and functions of neurons defined by multiple genetic characteristics)	2020

Winter Brain (Chair, Advances in cell-type specific detection and manipulation of neurotransmitters)	2020
CU neuroscience club	2019
Anesthesiology Department Grand Rounds (Anschutz)	2019
Behavioral Neuroscience Retreat (Keynote)	2018
Front Range Neuroscience Group	2018
Office of Animal Research	2018

Posters since starting at CU Boulder in 2018

* denotes senior/corresponding author as CU Boulder faculty

denotes author as CU Boulder faculty but not senior/corresponding author

Prevost ED, Lauridsen K, Ly A, **Root DH***. (2021). SHARCQ: A high-throughput method for slice histology atlas registration and cell quantification. CU Boulder Behavioral Neuroscience Departmental Retreat

Monroy-Tello R, Nunez L, **Root DH***. (2021). Neurobiology of Withdrawal-Induced Changes in Defensive Behavior. McNair Scholars Research Conference

Ly A, Barker A, Prevost E, McGovern DJ, **Root DH***. (2021). Live versus robotic predatory threat on foraging by bed nucleus of the stria terminalis GABA neurons. Society for Neuroscience

Ly A, Nunez L, Elvig S, McGovern DJ, Prevost E, Bates SHS, **Root DH***. (2021). Modulating RMTg GABA neurons in response to threats under opioid-induced states. European Behavioral Pharmacology Society

Ly A, Prevost E, McNulty C, Kilpatrick Z, **Root DH***. (2021). The role of extended amygdala cell-types in a foraging task and threat response in mice. International Behavioral Neuroscience Society.

McGovern DJ, Phillips A, Ro K, Prevost E, **Root DH***. (2021). Ventral tegmental area glutamate/GABA neurons contribute to consummatory reward behavior. SfN virtual connectome.

McGovern DJ, Polter AM, Mulcahy DJ, Ly A, Prevost E, **Root DH***. (2021). Ventral tegmental area glutamate neurons contribute to cue induced oxycodone seeking behavior. International Narcotics Research Conference.

McGovern DJ, Polter AM, Mulcahy DJ, Ly A, Prevost E, **Root DH***. (2021). Ventral tegmental area glutamate neurons contribute to cue induced oxycodone seeking behavior. European Behavioral Pharmacology Society (EBPS).

Fallon IP, Tanner MK, Tamalunas AM, **Root DH#**, Baratta MV, Greenwood BN. (2019). Voluntary wheel running prevents the behavioral sequelae of uncontrollable stress in females. Society for Neuroscience

McGovern DJ, Phillips A, **Root DH***. (2019). Neurochemical signaling of reward and aversion in ventral tegmental area glutamate neurons using genetically-encoded GABA and glutamate sensors. Society for Neuroscience

Root DH#, Barker DJ, Estrin DJ, Miranda-Barrientos JA, Liu B, Zhang S, Vautier F, Ramakrishnan

C, Kim YS, Fenno LE, Deisseroth K, Morales MF. (2019). Distinct roles of VTA glutamate, GABA and glutamate-GABA neurons in motivated behavior. Society for Neuroscience

Phillips A, McGovern D, Lee J, Ro K, Huynh D, Elvig S, Fegan K, **Root DH***. (2019). Oral prescription opioid-seeking behavior in male and female mice. Society for Neuroscience

Pierce AF, Burt EE, **Root DH#**, Donaldson ZR. (2019). Spatial and temporal dopamine dynamics underlying monogamous bonds. Society for Neuroscience

Pierce AF, Burt EE, **Root DH#**, Donaldson ZR. Spatial and temporal dopamine dynamics underlying monogamous bonds. (2019). Gordon Research Conference: Complexity and Diversity in Catecholamine Neurobiology: From Molecule to Circuits to Behavior

McGovern DJ, Phillips A, **Root DH*** (2019). Neurochemical signaling of reward and aversion in VTA glutamate neurons. Front range neuroscience group (selected for cover of program)

Ecton KL, Huynh DT, McGovern DJ, Phillips AG, Baratta MV*, **Root DH***. (2019). Role of ventral tegmental area glutamate neurons in mediating deleterious stress effects. Front range neuroscience group

McGovern DJ, Phillips A, **Root DH*** (2019). Monitoring in vivo GABA/Glutamate dynamics using genetically encoded fluorescent indicators. Colorado Neuroscience Symposium

McGovern DJ, Phillips A, **Root DH*** (2019). Neurochemical signaling of reward and aversion by VTA Glutamate neurons. Society for Neuroscience Nano symposium

Miranda-Barrientos JA, Chambers I, **Root DH**, Wang HL, Mateo-Semidey G, Liu B, Morales MF. (2019). Electrophysiological properties of ventral tegmental area combinatorial glutamate-GABA neurons. Society for Neuroscience

Ro K, Phillips A, Huynh D, Elvig S, **Root DH***. (2018). Cellular dissection of food intake. Front range neuroscience group

Estrin DJ, **Root DH**, Morales M. (2018). Ventral tegmental area glutamate neurons are functionally diverse. Society for Neuroscience

Root DH, Zhang S, Barker DJ, Miranda-Barrientos JA, Liu B, Wang HL, Morales MF. (2018). Glutamate and gaba co-transmission: Cell-types, distribution, synaptic and vesicular mechanisms. Society for Neuroscience