

## **GUSTAVO A. ARRIZABALAGA**

Indiana University School of Medicine  
Department of Pharmacology and Toxicology  
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### **CURRENT POSITION**

Professor, Departments of Pharmacology and Toxicology and Microbiology and Immunology, Indiana University School of Medicine (IUSM)

### **EDUCATION AND TRAINING**

Post-doctoral fellow, Stanford University School of Medicine, Stanford, CA 1999-2004

- Advisor: Dr. John Boothroyd
- Research topic: Molecular and genetic studies of egress in *Toxoplasma gondii*

Ph.D., Massachusetts Institute of Technology; Cambridge, MA 1992-1999

- Advisor: Dr. Ruth Lehmann
- Thesis: Molecular and genetic analysis of the *Drosophila* protein Nanos

B.S., Chemistry with Biology concentration, Haverford College, Haverford, PA 1988-1992

- Advisor: Dr. Julio de Paula
- Thesis: Biochemical and biophysical studies of electron transfer in plant photosynthesis

H.S., Colegio De La Salle, Bayamón, Puerto Rico 1984-1988

### **RESEARCH RELATED EMPLOYMENT**

2017-current Professor, Departments of Pharmacology and Toxicology and Microbiology and Immunology, Indiana University School of Medicine

2012-2017 Associate Professor, Departments of Pharmacology and Toxicology and Microbiology and Immunology, Indiana University School of Medicine

2011-2012 Director, Microbiology, Molecular Biology and Biochemistry Graduate Studies Program, University of Idaho, Moscow, ID

2004-2012 Faculty, WWAMI Medical Education Program, University of Idaho, Washington State University and University of Washington

2009-2014 Associate Professor with tenure, Department of Microbiology, Molecular Biology and Biochemistry (merged with Department of Biological Sciences in 2011), University of Idaho, Moscow, ID

2004-2009 Assistant Professor, Department of Microbiology, Molecular Biology and Biochemistry, University of Idaho, Moscow, ID

1999-2004 Post-doctoral fellow, Stanford University School of Medicine, Stanford, CA

1993-1999 Doctoral Student, Massachusetts Institute of Technology, Cambridge, MA

1992 Research Lab Technician, Dupont Pharmaceuticals, Wilmington, DE

1990-1992 Research associate, Haverford College, Haverford, PA

### **CURRENT AFFILIATIONS AND MEMBERSHIPS**

Affiliate Faculty, Department of Biochemistry and Molecular Biology, IUSM

Member, American Society of Microbiology (ASM)  
Member, American Society for Cell Biology (ASB)  
Member, American Society for Biochemistry and Molecular Biology (ASBMB)  
Member, American Society of Tropical Medicine and Hygiene (ASTMH)  
Member, SACNAS

## HONORS AND AWARDS

2017 Trustees Teaching Award, IUSM  
2012 Excellence in Teaching Award, WWAMI medical program, University of Idaho  
2011 Spotlited in October issue of The Minority Microbiology Mentor Newsletter of the American Microbiology Society  
2011 Commitment to Diversity Faculty Award, WWAMI medical program, University of Idaho  
2011 Excellence in Teaching Award, WWAMI medical program, University of Idaho  
2010 R.M. Wade Teaching Excellence Award, College of Agriculture and Life Sciences, University of Idaho  
2008 and 09 R.M. Wade Teaching Excellence Award Nominee, College of Agriculture and Life Sciences, University of Idaho  
2006 Carl Storm Fellowship, Gordon Research Conferences  
2000-2002 Post-doctoral Fellow, NIH NRSA  
1994-1998 Pre-doctoral Fellow, NIH-NIGMS  
1990-1992 Howard Hughes Scholar, Haverford College  
1992 Honors, Chemistry department Haverford College  
1992 Scholarship Improvement Prize, Haverford College  
1988-1992 Jose Padín Scholar, Haverford College

## PUBLICATIONS

### Journal articles

Panozzo-Zénere E.A., Porta E.O., **Arrizabalaga G.**, Fagnoli L., Khan S.I., Tekwani B.L., and Labadie, G.R., 2017 A minimalistic approach to develop new anti-apicomplexa polyamines analogs, *European Journal of Medicinal Chemistry*

Varberg, J.M., LaFavers, K.A., <sup>1</sup>Sullivan, W.J., <sup>1</sup>**Arrizabalaga, G.**, 2017 Characterization of Plasmodium Atg3-Atg8 interaction inhibitors identifies novel alternative mechanisms of action in *Toxoplasma gondii*, *Antimicrob Agents Chemother.*, PMID:29158278 <sup>1</sup>Senior authors contributed equally

Garbuz, T. and **Arrizabalaga, G.**, 2017 Lack of mitochondrial MutS homolog 1 in *Toxoplasma gondii* disrupts maintenance and fidelity of mitochondrial DNA and reveals metabolic plasticity, *Plos One*, PMID:29141004

Roiko, M.S., LaFavers, K., **Arrizabalaga, G.**, 2017 *Toxoplasma gondii*-positive human sera recognize intracellular tachyzoites and bradyzoites with diverse patterns of immunoreactivity, *Int J. for Parasitology*.

LaFavers, K.A, Márquez-Nogueras K.M., Coppens, I., Moreno, SNJ, **Arrizabalaga, G.**, 2017 A novel dense granule protein, GRA41, regulates timing of egress and calcium sensitivity in *Toxoplasma gondii*. *Cell Microb*, PMID: 28430089

Colinot, D.L., Garbuz, T., Bosland, M., Rice, S., Wang, L., Sullivan, W.J., <sup>1</sup>Jerde, T. <sup>1</sup>**Arrizabalaga, G.**, 2017 *Toxoplasma gondii*: a novel inducer of chronic prostatic

- inflammation and proliferative inflammatory microglandular hyperplasia in a mouse model of prostatic inflammation. *Prostate*, PMID: 28497488. <sup>1</sup>Senior authors contributed equally
- Padgett, L., <sup>1</sup>Sullivan, W.J., <sup>1</sup>**Arrizabalaga, G.**, 2016, Targeting of tail-anchored membrane proteins to subcellular organelles in *Toxoplasma gondii*. *Traffic*. 2017 Mar;18(3):149-158. PMID:27991712 <sup>1</sup> Senior authors contributed equally
- Varberg, J.M., Padgett, L.R., **Arrizabalaga, G.**, Sullivan, W.J., 2016. TgATAT-mediated  $\alpha$ -tubulin acetylation is required for division of the protozoan parasite *Toxoplasma gondii*. *mSphere*, Jan 20;1(1) 26. PMID: 27303695
- Charvat, R. and **Arrizabalaga, G.**, 2016. Oxidative stress generated during monensin treatment contributes to altered *Toxoplasma gondii* mitochondrial function. *Nature Scientific Reports*, Mar 15;6. PMID: 26976749
- Gaji, R., Johnson, D., Wang, M., Hudmon, A., and **Arrizabalaga, G.**, 2015. Phosphorylation of a Myosin motor by TgCDPK3 facilitates rapid initiation of motility during *Toxoplasma gondii* egress. *PLoS Pathog*. 1(11):e1005268. PMID: 26544049
- Benmerzouga, I., Checkley, L., Ferdig, M., **Arrizabalaga, G.**, Wek, R., and Sullivan, W., 2015. Guanabenz repurposed as an anti-parasitic with activity against acute and latent toxoplasmosis, *Antimicrob Agents Chemother*, 59(11):6939-45. PMID: 26303803
- Campodonico J., Kochhar K., **Arrizabalaga G.**, and Sevilla-Martir J., 2015. Assessing knowledge and perceptions related to preventive methods and treatment of malaria in the local endemic area of Trujillo, Honduras. *Hispanic HealthCare International Journal*, 13(2):97-108
- Treeck, M., Sanders, J., Gaji, R., LaFavers, K., Child, M., **Arrizabalaga, G.**, Elias, J., Boothroyd, J., 2014. A novel role of Calcium-dependent Kinase 3 in regulating metabolism in *Toxoplasma gondii* in addition to ionophore induced egress. *PLoS Pathogen*, 10(6):e1004197. PMID: 24945436
- Gaji, R., Checkley, L., Reese, M., Ferdig, M.T., and **Arrizabalaga, G.**, 2014. Expression of the essential kinase PfCDPK1 from *Plasmodium falciparum* in *Toxoplasma gondii* facilitates the discovery of novel antimalarial drugs. *Antimicrob Agents Chemother*, 58(5):2598-607. PMID: 24550330
- Garrison, E., Treeck, M., Ehret, M., Garbuz, T., Oswald, B.P., Settles, M., Boothroyd, J., **Arrizabalaga, G.**, 2012. A forward genetic screen reveals calcium-dependent kinase 3 is critical for calcium-induced egress in *Toxoplasma*. *Plos Pathogen*, 8(11). PMID: 23209419
- Lavine, M.D. and **Arrizabalaga, G.**, 2012, Analysis of Monensin Sensitivity in *Toxoplasma gondii* reveals autophagy as a mechanism for drug induced death. *Plos One*, 7(7):e42107. PMID: 22848721
- Hass, J., Garrison, E., Wicher, S., Knapp, B., Bridges N., McIlroy, D. and **Arrizabalaga, G.**, 2012. Synthetic osteogenic extracellular matrix formed by coated silicon dioxide nanosprings. *Journal of Bionanotechnology*, 10 (6). PMID: 22284364
- Kamau E., Meehan T., Lavine M.D., **Arrizabalaga, G.**, Mustata, G. and Boyle, J. 2011. A novel benzodioxole-containing inhibitors of *Toxoplasma gondii* growth alters the parasite cell cycle. *Antimicrob Agents Chemother*, 55(2): 745-55. PMID: 21947387

- Francia, M.E., Wicher S., Pace D.A., Sullivan, J., Moreno, S.N.J., and **Arrizabalaga, G.**, 2011. A *Toxoplasma* protein with homology to intracellular type Sodium Hydrogen Exchangers is required for osmotolerance and protein processing. *Experimental Cell Research*. 317(10):1384-96. PMID: 21501607
- Lavine, M.D. and **Arrizabalaga, G.**, 2011. The antibiotic monensin causes cell cycle disruption of *Toxoplasma gondii*, mediated through the DNA repair enzyme TgMSH-1. *Antimicrob Agents Chemother*, 55(2): 745-55. PMID: 21098240
- Garrison, E. and **Arrizabalaga, G.**, 2009. Disruption of a mitochondrial homolog of a MutS DNA Repair Enzyme confers drug resistance in the pathogenic parasite *Toxoplasma gondii*. *Molecular Microbiology*, 72(2):425-41. PMID 19291232
- Lavine, M.D. and **Arrizabalaga, G.**, 2009. Induction of mitotic S-phase of host and neighboring cells by *Toxoplasma gondii* enhances parasite invasion. *Molecular and Biochemical Parasitology*, 164(1):95-9. PMID: 19111577
- Saeij, J., **Arrizabalaga, G.** and Boothroyd J.C. 2008. A cluster of four surface antigen genes specifically expressed in bradyzoites, *SAG2CDXY*, plays an important role in *Toxoplasma gondii* persistence. *2008 Immunity and infection*, 76(6):2402-10. PMID: 18347037
- Lavine, M and **Arrizabalaga, G.**, 2008 Exit from host cells by the pathogenic parasite *Toxoplasma gondii* does not require motility. *Eukaryotic Cell*, 7(1): 131-140. PMID: 17993573
- Fruth, I.A. and **Arrizabalaga G.**, 2007. *Toxoplasma gondii*: Induction of egress by the potassium ionophore nigericin. *International Journal of Parasitology, International Journal of Parasitology*, 37(14): 1559-67. PMID: 17643508
- Lavine, M.D., Knoll, L.J., Rooney, P.J. and **Arrizabalaga, G.**, 2007. A *Toxoplasma gondii* mutant defective in responding to calcium fluxes shows reduced in vivo pathogenicity. *Molecular and Biochemical Parasitology*, 155(2): 113-122. PMID: 17643508
- Saeij, J. P. J., Boyle, J. P., Grigg, M.E., **Arrizabalaga G.**, and Boothroyd J. C. 2005. Bioluminescence imaging of *Toxoplasma* infection in living mice reveals dramatic differences between strains. *Infect Immun* 73(2); 695-702. PMID: 15664907
- Karasov, A, Boothroyd J.C. and **Arrizabalaga, G.**, 2005. Identification and disruption of a rhoptry localized Sodium Hydrogen Exchanger in *Toxoplasma gondii*. *International Journal of Parasitology*, 35 (3); 285-291. PMID: 15722080
- Arrizabalaga, G.**, Ruiz, F., Moreno, S. and Boothroyd J.C., 2004. Ionophore-resistant mutant of *Toxoplasma gondii* reveals involvement of a sodium/hydrogen exchanger in calcium regulation. *Journal of Cell Biology*: 165(5):653-62,. PMID: 15173192
- Camps, M., **Arrizabalaga, G.** and Boothroyd J.C., 2002. An rRNA mutation identifies the apicoplast as the target for clindamycin in *Toxoplasma gondii*. *Molecular Microbiology* 43(5):1309-18. PMID: 11918815
- Black, M.W., **Arrizabalaga, G.** and Boothroyd J.C., 2000. Ionophore-resistant mutants of *Toxoplasma gondii* reveal host-cell permeabilization as an early event in egress. *Mol. Cell Bio.* 20; 9399-9408.

**Arrizabalaga, G.** and Lehmann, R., 1999. A selective screen reveals discrete functional domains in *Drosophila* Nanos. *Genetics* 153; 1825-1838. PMID: 10581288

Book Chapters, Reviews and Perspectives (all peer reviewed)

Yang, C. and **Arrizabalaga, G.** 2017. The serine/threonine phosphatases of apicomplexan parasites. *Molecular Microbiology*

I. J. Blader, **G. Arrizabalaga**, and W. J. Sullivan. The Role of Host- And Parasite-Encoded Kinases in *Toxoplasma*-Host Interactions.” Invited Chapter Review for “Protein Phosphorylation in Eukaryotic Parasites: Potential for Chemotherapy”. Edited by Christian Doerig, Gerald Spaeth, Martin Wiese, and Paul Selzer. 2013.

**Arrizabalaga G.**, 2011. A fine balance between life and death: modulation of BCL-2 family members by *Toxoplasma gondii*. *Frontier in Cellular and Infection Microbiology*. 2:39

Lavine, M.D., and **Arrizabalaga, G.**, 2007. Invasion and egress by the obligate intracellular parasite *Toxoplasma gondii*: potential targets for the development of new antiparasitic drugs. *Current Pharmaceutical Design*. 13, 641-651. PMID: 17346179

**Arrizabalaga, G.**, Boothroyd J.C., 2004. Role of calcium during invasion and egress in *Toxoplasma gondii*. *International Journal of Parasitology* 34; 361-368. PMID: 15003496

Articles (not peer reviewed)

**Arrizabalaga G.** and Sullivan W.J. Played by a parasite, *Scientific American Mind*, March 2015 pp 62-67; Reposted in Salon.com; Reprinted in *Scientific American*, September 2015, translated to Spanish and published in *Investigación y Ciencia* December 2015; translated to German and published December 2015

**FUNDING**

Currently Active Support

1R01AI123457	4/1/2016-3/30/2021	\$2,507,766
NIH	Role: Principal investigator (MPI with Dr. Moritz Treeck)	
Dissecting the calcium dependent phosphorylation network of <i>Toxoplasma gondii</i>		
1 R21AI125822	7/1/2016-6/30/2018	\$275,000
NIH	Role: Principal investigator (MPI with Dr. William Sullivan)	
Elucidating new and old roles for autophagy-like genes in <i>Toxoplasma gondii</i>		

Completed grants

R21AI108393-01A1	2/2/2015-1/31/2017	\$275,000
NIH	Role: Principal investigator	
Dissecting the role of <i>Toxoplasma</i> CDPK3 in parasite propagation and virulence		
1R21AI119516-01	5/1/2015-4/3/2017	\$275,000
NIH	Role: Principal investigator	
Calcium signaling in the parasitophorous vacuole of <i>Toxoplasma gondii</i>		
RO1 AI 89808-01	7/1/2010-6/30/2014	\$900,000
NIH	Role: Principal investigator	
Dissecting a novel mechanism of drug-induced death in <i>Toxoplasma gondii</i>		
RO3 AI 101624	7/1/2012-6/30/2014	\$100,000

NIH		Role: Principal investigator
Characterization of calcium signaling proteins in <i>Toxoplasma gondii</i>		
13GRNT1604000	7/1/2013-6/30/2015	\$100,000
American Heart Association		Role: Principal investigator
Dissecting the role of a unique kinase in the propagation and virulence of the cardiac pathogen <i>Toxoplasma gondii</i>		
RSG-08-19-01-MBC	7/01/2008-6/30/2012	\$750,000
American Cancer Society		Role: Principal investigator
Initiation of motility in the opportunistic pathogen <i>Toxoplasma gondii</i> .		
K22 AI061293	9/1/2004-8/30/2007	\$250,000
NIH		Role: Principal investigator
<i>Toxoplasma gondii</i> egress		

### **INVITED LECTURES AND TALKS**

Francis Crick Institute, London UK, May 2016

Clark Atlanta University, Atlanta, GA, April 2016

Annual meeting of the American Society of Tropical Medicine and Hygiene, Philadelphia, October 2015

Midwest Microbial Pathogenesis Conference, Indianapolis, IN, August 2015

Northern Illinois University Chicago, IL, February 2015

University of California Irvine, Irvine, CA, December 2014

Congress of the Argentinean Society of Protozoology Annual Meeting, Mar del Plata, Argentina, November 2014

Molecular Parasitology Meeting Woods Hole, Massachusetts, September 2014

University of South Florida, Tampa, FL, October 2013

Midwest Neglected Infectious Diseases Meeting, Notre Dame, IN, September 2013

International Congress on Toxoplasmosis, Oxford, UK, June 2013

University of Indiana, Indianapolis, IN, September 2011

International Congress on Toxoplasmosis, Ottawa, Canada, June 2011

University of Oklahoma Health Sciences Center, Oklahoma City, OK, January 2011

NIMBioS Investigative Workshop on Modeling *Toxoplasma gondii*, Knoxville, TN, March 2010

Montana State University, Bozeman, MT, February 2010

University of Texas Medical Center Houston, TX 2008

Temple University, Philadelphia, PA, 2008

Albany Medical College, Albany, NY 2008

Johns Hopkins University Medical Institutions, Baltimore, MD, December 2008

Argentinian Society of Protozoology, Rosario, Argentina, November 2008

College of Southern Idaho, Twin Falls, Idaho, September 2007

North West Reproductive Society, Moscow, Idaho, March 2007.

Washington State University, CRB seminar series, Pullman, WA, March, 2007

## TEACHING

Experience designing, chairing and teaching a broad range of courses for undergraduate, graduate, medical and physician assistant students. Topics taught include molecular and medical parasitology, microbiology, cardiac physiology and pharmacology, cytoskeletal regulation, and cell biology.

### Undergraduate

MMBB 463 Molecular Parasitology (UI) Course developer and lecturer	Spring 2007-2010 45 hrs
MMBB 487 Eukaryotic molecular genetics (University of Idaho, UI) Lecturer	Fall 2004 3 contact ho

### Graduate

F850 Experimental Design and Grant Writing (IUSM) Lecturer	Summer 2017 1.5 hrs
G728 Fundamental Concepts of Infection and Pathogenesis (IUSM) Lecturer	Spring 2017 2 hrs/class
G717 Cellular Basis of System Biology (IUSM) Lecturer	Fall 2014-16 4 hrs/class
G745 Intracellular Signal Transduction (IUSM) Lecturer	Spring 2014-17 8 hrs/class
J829 Current Topics in Microorganisms (IUSM) Lecturer	Fall 2012, 2014 3 hrs/class
MMBB 589 Adv. Top. Microbiology, Mol. Biology, Biochemistry (UI) Lecturer	Spring 2005-12 6 hrs/class
MMBB 541 Biochemistry (UI) Lecturer	Fall 2004 2 hrs/class

### Postgraduate

F604 Medical Pharmacology I Cardiac Block Lecturer	Spring 2016 6 hrs/class
K818 Principals in Medical Pharmacology I Cardiac Block Lecturer	Fall 2015, 2016 6 hrs/class
J602 Medical Microbiology I Parasitology Block (IUSM) Lecturer	Spring 2013-2017 4 hrs/class
Med 534 Medical Microbiology (UI WWAMI) Lecturer	Spring 2011, 2012 12 hrs/class
Medical Cell Physiology (U. Alaska WWAMI) Invited lecturer	Spring 2008, 2009 8 hrs/class
Med 512 Medical Cell Physiology (UI WWAMI) Lecturer, Course chair	Fall 2004-2011 20 hrs/class

## MENTORING

### In lab

5 postdoctoral fellows, 6 PhD students, 4 MS students, 3 MD students, 26 undergraduate students, 1 visiting scholar, 4 high school students

### In rotations, thesis, advisory and mentoring committees and as academic advisor

4 faculty, 2 postdoctoral fellows, 32 graduate students, over 100 undergraduate students

### Through National Research Mentoring Network (NRMN)

8 postdoctoral fellows from Purdue University, University of Minnesota, University of Utah, and UCLA

Mentor Training Facilitator, attended 2-day training at University of Wisconsin March 2017 and implemented Entering Research curriculum for IUSM entering graduate students starting Fall 2017

#### Others

SACNAS, IUPUI and IU School of Medicine Faculty Advisor	2014-present
ABRCMS 2016 and 2017 Invited Speaker, Organized, led and Participated in panel focused on the graduate admissions process	2016
Clark Atlanta University, Atlanta, GA, led mentoring session focused on applying to graduate schools and pursuing research careers.	2016
Met with University administrators to establish recruitment pipelines for graduate students and postdoctoral fellows	
Spelman College Research Day poster judge, Atlanta, GA	2016
ABRCMS, abstract and poster judge	2008-2016
MMBB Student Club Faculty Advisor (UI)	2006-2012
Creator and organizer of MMBB Undergraduate Research Symposium	2005-2012

#### **REVIEWING AND EDITING EXPERIENCE**

Scientific Reports, Editor

National Institute of Health, Permanent member PTHE 2017-2022

American Heart Association permanent grant reviewer 2008-2012

National Institute of Health, ad-hoc reviewer (over 15 study sessions)

National Science Foundation, ad-hoc grant reviewer

Program reviewer for the MRC National Institute of Medical Research, London

Deutsche Forschungsgemeinschaft, ad-hoc grant reviewer

French National Research Agency, ad-hoc grant reviewer

Welcome Trust, ad-hoc grant reviewer

Ad-hoc grant reviewer, Welcome Trust

Manuscript reviewer for over 100 manuscripts, including for Plos Pathogens, PLoS Genetics, PLoS One Journal of Biological Chemistry, Molecular Microbiology, Eukaryotic Cell, Autophagy, Cellular Microbiology, Infection and Immunity, and mBio.

#### **SERVICE (Key examples)**

IBMG Admissions Committee Pharmacology Representative	2014-present
IUSM Diversity Council Member	2015-present
IUSM Faculty Steering Committee Department Rep	2016-2017t
IBMG recruitment and outreach travel to ABRCMS	2016 and 2017
IBMG recruitment and outreach travel to Clark Atlanta University and Spelman College	2016
IUSM Pharmacology and Toxicology Faculty Search Committee, Chair	2015, 2016, 2017
Pharmacology and Toxicology Seminar Series Director (IUSM)	2013-17

University of Idaho Juntura (Diversity) Committee Chair and Member (UI)	2007-2009
MABB Graduate Admission Committee Member (UI)	2006-2008
Departmental Curriculum Committee Member (UI)	2007-2010
University of Idaho, McNair Program Advisory Committee Member	2005-2012