

# Joel S. Freundlich

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## RESEARCH INTERESTS

Dr. Freundlich leads a research group of eleven scientists pursuing the development and application of computational, chemical, and biological platforms to study infectious diseases.

- How do antibacterial small molecules leverage the modulation of more than one target to achieve significant cidality?
- How are potent antibacterial agents metabolized by the mammalian host or the bacterium in detoxification and/or activation events with a specific focus on achieving a quantitative mass balance?
- How may the properties (physiochemical, ADME, biological) of chemical tools be predicted and then evolved via machine learning methodologies?

## PROFESSIONAL EXPERIENCE

**RUTGERS UNIVERSITY-NEW JERSEY MEDICAL SCHOOL**, Newark, NJ July 2017 to present

Associate professor with Tenure (Department of Pharmacology & Physiology)

Associate professor with Tenure (Department of Medicine)

Member (Center for Emerging and Reemerging Pathogens)

Member (Graduate Program in Medicinal Chemistry)

Courses taught:

The Chemical Biology of Pathogens GSBS 5160Q – Spring 2015 – 2017

Medical School Foundations II (7 lectures) – Winter 2016 – 2017

Select Agent Biology MSBS N517Q – Spring 2012 - 2013

Pharmacology PHRM 7206 – Spring 2012 - 2018

Advanced Concepts in I<sup>3</sup> GSBS 5022Q – Spring 2012, 2013, 2015, 2016

Topics in Pharmacology PHPY-N5030 – Spring 2016 – 2017

Introduction to Genomics, Proteomics, and Bioinformatics MBGC 5002Q – Spring 2015, 2017 – 8

University Activities:

Faculty Committee on Appointments and Promotions (2017–)

Admissions Committee for M.D./Ph.D. candidates (2013–)

Molecular Biology-Genetics-Cancer Track Oversight Committee member (2013–)

Institutional Biosafety Committee member (2013 –)

**RUTGERS UNIVERSITY-NEW JERSEY MEDICAL SCHOOL**, Newark, NJ July 2014 to June 2017

Associate professor (Department of Pharmacology & Physiology)

Associate professor (Department of Medicine)

Member (Center for Emerging and Reemerging Pathogens)

**RUTGERS UNIVERSITY-NEW JERSEY MEDICAL SCHOOL**, Newark, NJ May 2011 to June 2014  
Assistant professor (Department of Pharmacology & Physiology)  
Assistant professor (Department of Medicine)  
Member (Center for Emerging and Reemerging Pathogens)

**TEXAS A&M UNIVERSITY**, College Station, TX March 2006 to April 2011  
Senior research scientist (Department of Biochemistry & Biophysics)

- Led research group of 5 – 7 researchers (typically two Ph.D. staff scientists, two post-doctoral associates, and one to three undergraduates) to study the fundamental biology pertinent to *Mycobacterium tuberculosis* and *Plasmodium falciparum*.

**RUTGERS UNIVERSITY**, Piscataway, NJ March 2009 to May 2011  
Visiting professor (Department of Medicinal Chemistry)

- Taught Pharmaceutical Chemistry (30:715:306) in Spring 2010

**PRINCETON UNIVERSITY**, Princeton, NJ March 2006 to March 2009  
Visiting senior research scholar (Department of Chemistry)

- Garnered internal grant support to conduct interdisciplinary research and education programs in infectious diseases through the Grand Challenges Initiative in Global Health. Mentored four undergraduate students in the laboratory and seven students in junior thesis work.

**JACOBUS PHARMACEUTICALS**, Princeton, NJ November 2003 to March 2006  
Senior scientist

- Responsible for project leadership functions, including compound design using molecular modeling tools, management of SAR database, and coordination of biological testing of compounds through academic collaborators.

**PROVID PHARMACEUTICALS**, Piscataway, NJ May 2003 to October 2003  
Consultant

- Investigated design and synthesis of small molecule therapeutics for Huntington's disease.

**LOCUS PHARMACEUTICALS**, Blue Bell, PA April 2001 to May 2003  
Senior Scientist

- Contributed to IND filing of a novel cell cycle inhibitor.
- Utilized rapid design and synthesis approach in the hit generation stage to investigate six biological targets in two years.

**PRAECIS PHARMACEUTICALS**, Piscataway, NJ June 1998 to March 2001  
Scientist II *January 2000 to March 2001*  
Scientist I *June 1998 to January 2000*

- Contributed to IND filings for Apan, an Alzheimer's disease therapeutic which inhibits the aggregation of  $\beta$ -amyloid into neurotoxic species, and PPI-2458, an anti-angiogenic therapeutic for non-Hodgkins lymphoma and rheumatoid arthritis.
- Coordinated research efforts of six chemists and biological studies with biochemistry group in Cambridge, MA and CROs.

**COLGATE-PALMOLIVE COMPANY**, Piscataway, NJ June 1996 to June 1998  
Research Scientist - Advanced Technology Group

- Synthesized small organic molecules, modified amino acids, and polyamides and screened for their use in controlling the structure of aluminum and zirconium complexes.

## EDUCATION

## MASSACHUSETTS INSTITUTE OF TECHNOLOGY

### Ph.D. in Organic Chemistry, 1996

- Thesis under 2005 Nobel Prize in Chemistry recipient Richard R. Schrock on “Metal-Ligand Multiple Bonds in Organometallic Complexes Featuring Tren-Based Ligand Systems.”
- Synthesized triamidoamine ligand complexes of tantalum, niobium, and tungsten as models for olefin and alkyne metathesis catalysts.

## CORNELL UNIVERSITY

### Master of Engineering (Chemical) with Dean’s certificate in Engineering Management, 1992

- Modeled the energetics of pyridine-metal surface interactions by performing Extended Hückel Molecular Orbital Calculations with 1981 Nobel Prize in Chemistry recipient Roald Hoffmann.
- Devised synthetic route towards the DNA lesion product common to spores with Tadhg P. Begley.

### Bachelor of Science in Chemical Engineering with Distinction, 1991

- Synthesized imidazole-based molecules to examine the mechanism of  $\beta$ -glucosidase inhibition with Bruce Ganem.
- Utilized the vicinal tricarbonyl moiety in the total synthesis of complex organic molecules with Harry H. Wasserman (Yale University).

## PROFESSIONAL ACTIVITIES

### NIH Study Section Member

ZRG1 IMST-L (11) B Small Business: Biological Chemistry, Biophysics and Drug Discovery (2012–2013)

NIH Study Section U.S.-South African Program for Collaborative Biomedical Research RFA (2014)

ZRG1 IMST-L 51 New Tools to Aid the Identification, Tracking, Manipulation, and Analysis of Glycans and their Functions and 52 -New Adaptations to Simplify Existing Technologies for Manipulation and Analysis of Glycans (2017)

ZRG1 BCMB-G 02 M, Member Conflict: Biological Chemistry and Macromolecular Biophysics

### Symposia Chair

- “Tuberculosis: Biology and Emerging Therapeutics,” American Chemical Society National Meeting 03/17/2014
- “Advances in Virtual High-Throughput Screening,” American Chemical Society National Meeting 04/10/2013

### Editorial Board

- Antimicrobial Agents and Chemotherapy (2017 –)

### Journal Referee

Nature Communications, Nature Chemical Biology, Cell Chemistry and Biology, Cell Host Microbe, ACS Chemical Biology, ACS Infectious Diseases, Journal of Medicinal Chemistry, Journal of the American Chemical Society, Journal of Chemical Information and Modeling, Bioorganic and Medicinal Chemistry Letters

### Scientific Advisor Board

Hereditary Neuropathy Foundation, Phoenix Nest, Inc., Collaborations Pharmaceuticals

### Member

- American Chemical Society
- American Society for Microbiology

## PUBLICATIONS

71. Lane, T. R., Massey, C., Comer, J. E., Anantpadma, M., **Freundlich, J. S.**, Davey, R. A., Madrid, P. B., Ekins, S.,\* “Repurposing The Antimalarial Pyronaridine Tetrphosphate To Protect Against Ebola Virus Infection,” *PloS Neglected Tropical Diseases*, **2019**, *13*, in press.

70. Wang, X., Inoyama, D., Russo, R., Li, S.-G., Jadhav, R., Stratton, T. P., Mittal, N., Bilotta, J. A., Singleton, E., Kim, T., Paget, S. D., Pottorf, R. S., Ahn, Y.-A., Davila-Pagan, A., Kandasamy, S., Grady, C., Hussain, S., Soteropoulos, P., Zimmerman, M. D., Ho, H. P., Park, S., Dartois, V., Ekins, S., Connell, N., Kumar, P., **Freundlich, J. S.**,\* “Antitubercular Triazines: Optimization and Intrabacterial Metabolism,” *Cell Chemical Biology*, **2019**, *26*, in press.
69. Wang, X., Perryman, A. L., Li, S.-G., Paget, S. D., Stratton, T. P., Lemenze, A., Olson, A. J., Ekins, S., Kumar, P., **Freundlich, J. S.**,\* “Intrabacterial Metabolism Obscures the Successful Prediction of an InhA Inhibitor of *Mycobacterium tuberculosis*,” *ACS Infectious Diseases*, **2019**, *5*, in press.
68. Ordonez, A. A., Carroll, L. S., Abishek, S., Mota, F., Ruiz-Bedoya, C. A., Klunk, M. H., Singh, A. K., **Freundlich, J. S.**, Mease, R. C., Jain, S. K., “Radiosynthesis and PET Bioimaging of <sup>76</sup>Br-Bedaquiline in a Murine Model of Tuberculosis,” *ACS Infectious Diseases*, **2019**, *5*, in press.
67. Anantpadma, M., Lane, T., **Freundlich, J. S.**, Davey, R. A., Madrid, P. B., Ekins, S., “The Natural Product Eugenol is Active Against the Ebola Virus *In Vitro*,” *Pharmaceutical Research*, **2019**, *36*, 104.
66. Daher, S. S., Jin, X., Patel, J., **Freundlich, J. S.**, Buttaro, B., Andrade, R. B., “Synthesis and Biological Evaluation of Solithromycin Analogs Against Multidrug Resistant Pathogens,” *Bioorganic and Medicinal Chemistry Letters*, **2019**, 1386.
65. Waldron, E. J., Snyder, D., Fernandez, N., Sileo, E., Inoyama, D., **Freundlich, J. S.**, Waters, C. M., Cooper, V. S., Neiditch, M. B., “Structural Basis of DSF Recognition by its Receptor RpfR and its Regulatory Interaction with the DSF Synthase RpfF,” *PLoS Biology*, **2019**, *17*, e3000123. PMID: 30716063
63. Anantpadma, M., Lane, T., Zorn, K. M., Lingerfelt, M. A., Clark, A. M., **Freundlich, J. S.**, Davey, R. A., Madrid, P. B., Ekins, S.,\* “Ebola Virus Bayesian Machine Learning Models Discover New *In Vitro* Leads,” *ACS Omega*, **2019**, *4*, 2353. PMID: 30729228
62. Gallardo-Macias, R., Kumar, P., Jaskowski, M., Richmann, T., Shrestha, R., Russo, R., Singleton, E., Zimmerman, M. D., Ho, H. P., Dartois, V., Connell, N., Alland, D., **Freundlich, J. S.**,\* “Optimization of *N*-benzyl-5-nitrofuranyl-2-carboxamide as an antitubercular agent,” *Bioorganic and Medicinal Chemistry*, **2019**, *29*, 601. PMID: 30600207
61. Kumar, P., Capodagli, G. C., Awasthi, D., Shrestha, R., Maharaja, K., Sukheja, P., Li, S.-G., Inoyama, D., Zimmerman, M., Liang, H. P., Sarathy, J., Mina, M., Rasic, G., Russo, R., Perryman, A. L., Richmann, T., Gupta, A., Singleton, E., Verma, S., Husain, S., Soteropoulos, P., Wang, Z., Morris, R., Porter, G., Agnihotri, G., Salgame, P., Ekins, S., Rhee, K. Y., Connell, N., Dartois, V., Neiditch, M. B.,\* **Freundlich, J. S.**,\* Alland, D.,\* “Synergistic Lethality of a Binary Inhibitor of *Mycobacterium tuberculosis* KasA,” *mBio*, **2018**, *9*, e02101. PMID: 30563908
60. Mori, G., Orena, B. S., Franch, C., Mitchenall, L. A., Godbole, A. A., Rodrigues, L., Zemanová, J., Huszár, S., Forbak, M., Lane, T. R., Sabbah, M., Deboosere, N., Frita, R., Vandeputte, A., Baulard, A., Russo, R., Connell, N., Veilleux, C., Kumar, R., Kumar, P., **Freundlich, J. S.**, Brodin, P., Ainsa, J. A., Nagaraja, V., Maxwell, A., Mikušová, K., Pasca, M. R., Ekins, S.,\* “The EU approved antimalarial pyronaridine shows antitubercular activity and synergy with rifampicin, targeting RNA polymerase,” *Tuberculosis* **2018**, *112*, 98. PMID: 30205975
59. Perryman, A. L., Patel, J. S., Russo, R., Singleton, E., Connell, N., Ekins, S., **Freundlich, J. S.**,\* “Naïve Bayesian Models for Vero Cell Cytotoxicity,” *Pharmaceutical Research* **2018**, *35*, 170. PMID: 29959603
58. Lane, T., Russo, D. P., Zorn, K.M., Clark, A.M., Korotcov, A., Tkachenko, V., Reynolds, R.C., Perryman, A. L., **Freundlich, J.S.**, Ekins, S.,\* “Comparing and Validating Machine Learning Models for *Mycobacterium tuberculosis* Drug Discovery,” *Molecular Pharmaceutics* **2018**, *15*, 4346. PMID: 29672063

57. Inoyama, D., Paget, S. D., Russo, R., Kandasamy, S., Kumar, P., Singleton, E., Occi, J., Tuckman, M., Zimmerman, M. D., Ho, H. P., Perryman, A. L., Dartois, V., Connell, N., **Freundlich, J.S.**,\* “Novel Pyrimidines as Antitubercular Agents,” *Antimicrobial Agents and Chemotherapy* **2018**, *61*, e02063. PMID: 29311070
56. Ekins S.,\* Clark A., Perryman A., Tkachenko V., Korotcov A., **Freundlich J.S.**, Accessible Machine Learning Approaches for Toxicology, In *Computational Toxicology: Risk Assessment For Chemicals*, Ekins S, John Wiley and Sons, **2018**.
55. Chu, J., Vila Farres, X., Inoyama, D., Gallardo-Macias, R., Jaskowski, M., Satish, S., **Freundlich, J.S.**, Brady, S.F.,\* “Human microbiome inspired antibiotics with improved  $\beta$ -lactam synergy against MDR *Staphylococcus aureus*,” *ACS Infectious Diseases* **2018**, *4*, 33-38. PMID: 28845973
54. Stratton, T.P., Perryman, A.L., Vilchère, C., Russo, R., Li, S.-G., Patel, J.S, Singleton, E., Ekins, S., Connell, N., Jacobs Jr., W.R., **Freundlich, J.S.**,\* “Addressing the Metabolic Stability of Antituberculars through Machine Learning,” *ACS Medicinal Chemistry Letters* **2017**, *8*, 1099. PMID: 29057058
53. Kumar, P., Chauhan, V., Silva, J. R. A., Lameira, J., d’Andrea, F., Li, S.-G., Ginell, S. L., **Freundlich, J. S.**, Alves, C. N., Bailey, S., Cohen, K. A., Lamichhane, G.,\* “*Mycobacterium abscessus* L,D-transpeptidases are susceptible to inactivation by carbapenems and cephalosporins but not penicillins,” *Antimicrobial Agents and Chemotherapy* **2017**, *61*, e00866. PMID: 28760902
52. Awasthi, D., **Freundlich, J.S.**,\* “Antimycobacterial Metabolism: Illuminating *Mycobacterium tuberculosis* Biology and Drug Discovery,” *Trends in Microbiology* **2017**, *25*, 756. PMID: 28622844
51. Vilchère, C., Hartman, T., Weinrick, B., Leung, L. W., **Freundlich, J.S.**, Jacobs Jr., W.R.,\* “Enhanced respiration prevents drug tolerance and drug resistance in *Mycobacterium tuberculosis*,” *Proceedings of the National Academy of Science USA* **2017**, *114*, 4495. PMID: 28396391
50. Sukheja, P., Kumar, P., Mittal, N., Li, S.-G., Singleton, E., Russo, R., Perryman, A. L., Shrestha, R., Awasthi, D., Husain, S., Soteropoulos, P., Brukh, R., Connell, N., **Freundlich, J.S.**, Alland, D.,\* “A novel small molecule inhibitor of the *Mycobacterium tuberculosis* menaquinone methyltransferase MenG is cidal to both growing and nutritionally-deprived persister cells,” *mBio* **2017**, *8*, e02022. PMID: 28196957
49. Vila-Farres, X., Chu, J., Inoyama, D., Ternei, M.A., Lemetre, C., Cohen, L.J., Cho, W., Reddy, B.V., Zebroski, H.A, **Freundlich, J.S.**, Perlin, D.S., Brady, S.F.,\* “Antimicrobials inspired by nonribosomal peptide synthetase gene cluster,” *Journal of the American Chemical Society* **2017**, *139*, 1404. PMID: 28055186
48. Kumar, P., Kaushik, A., Lloyd, E. P., Li, S.-G., Mattoo, R., Ammerman, N. C., Bell, D. T., Perryman, A. L., Zandi, T. A., Ekins, S., Ginell, S. L., Townsend, C. A., **Freundlich, J.S.**, Lamichhane, G.,\* “Non-classical transpeptidases yield insight into new antibacterials,” *Nature Chemical Biology* **2017**, *13*, 54. PMID: 27820797
49. Chu, J., Vila-Farres, X., Inoyama, D., Ternei, M., Zebroski, H. A., Cohen, L. J., Gordon, E. A., Reddy, B. V. B., Charlop-Powers, Z., Gallardo-Macias, R., Jaskowski, M., Satish, S., Park, S., Perlin, D. S., **Freundlich, J. S.**, and Brady, S.,\* “Syn-BNPs: Discovery of antibiotics using primary sequence data from the human microbiome,” *Nature Chemical Biology* **2016**, *12*, 1004. PMID: 27748750
47. Ekins, S.,\* Perryman, A. L., Clark, A. M., Reynolds, R. C., and **Freundlich, J. S.**, “Machine Learning Model Analysis with Small Molecules Tested in a Mouse Model of *Mycobacterium tuberculosis* Infection (2014-2015),” *Journal of Chemical Information and Modeling* **2016**, *56*, 1332. PMID: 27134728
46. Ekins, S.,\* Mietchen, D., Coffee, M., Stratton, T., **Freundlich, J.**, Freitas-Junior, L., Muratov, E., Siqueira-Neto, J., Williams, A., Andrade, C., “Open drug discovery for the Zika virus,” *F1000Research* **2016**, *5*, 150. PMID: 27134728

45. Ekins, S., \* **Freundlich, J. S.**, Clark, A. M., Anantpadma, M., Davey, R., and Madrid, P. B., "Machine Learning Models Identify Molecules Active Against the Ebola Virus *In Vitro*," *F1000Research* **2016**, 1091. PMID: 26834994
44. Perryman, A. L., Stratton, T. P., Ekins, S., and **Freundlich, J. S.**, \* "Predicting Mouse Liver Microsomal Stability with "Pruned" Machine Learning Models and Public Data," *Pharmaceutical Research* **2016**, 33, 433. PMID: 26415647
43. Ekins, S., Madrid, P. B. \*, Sarker, M., Li, S. -G., Mittal, N., Kumar, P., Wang, X., Stratton, T. P., Zimmerman, M., Talcott, C., Bourbon, P., Travers, M., Yadav, M., and **Freundlich, J. S.**, \* "Combining Metabolite-Based Pharmacophores with Bayesian Machine Learning Models for *Mycobacterium tuberculosis* Drug Discovery," *PloS ONE* **2015**, 10, e0141076. PMID: 26517557
42. Clark, A. M., Dole, K., Coulon-Spektor, A., McNutt, A., Grass, G., **Freundlich, J. S.**, Reynolds, R. C., and Ekins, S., "Open Source Bayesian Models: I. Application to ADME/Tox and Drug Discovery Datasets," *Journal of Chemical Information and Modeling* **2015**, 55, 1231. PMID: 25994950
41. Forbes, L., Ebsworth-Mojica, K., DiDone, L., Li, S.-G., **Freundlich, J. S.**, Connell, N., Dunman, P. M., Krysan, D. J., "A high throughput screening assay for anti-mycobacterial small molecules based on adenylate kinase release as a reporter of cell death," *PloS ONE* **2015**, 10, e0129234. PMID: 26098625
40. Li, S.-G., Vilchèze, C., Chakraborty, S., Wang, X., Kim, H., Anisetti, M., Ekins, S., Rhee, K. Y., Jacobs Jr., W. R., **Freundlich, J. S.**, \* "Evolution of a thienopyrimidine antitubercular relying on medicinal chemistry and metabolomics insights," *Tetrahedron Letters* **2015**, 56, 3246. PMID: 26257441
39. Ekins, S., Litterman, N. K., Arnold, R. J., Burgess, R. W., **Freundlich, J. S.**, Gray, S. J., Higgins, J. J., Langley, B., Willis, D. E., Notterpek, L., Pleasure, D., Sereda, M. W., Moore, A., "A brief review of recent Charcot-Marie-Tooth research and priorities," *F1000Research* **2015**, 4, 53. PMID: 25901280
38. Perryman, A. L., Yu, W., Wang, X., Ekins, S., Forli, S., Li, S.-G., **Freundlich, J. S.**, Tonge, P. J., Olson, A. J., "A Virtual Screen Discovers Novel, Fragment-Sized Inhibitors of *Mycobacterium tuberculosis* InhA," *Journal of Chemical Information and Modeling* **2015**, 55, 645. PMID: 25636146
37. Ekins, S., **Freundlich, J. S.**, Coffee, M., "A common feature pharmacophore for FDA-approved drugs inhibiting the Ebola virus," *F1000Research* **2014**, 3, 277. PMID: 25653841
36. Al Olaby, R. R., Cocquerel, L., Zemla, A., Saas, L., Dubuisson, J., Vielmetter, J., Marcotrigiano, J., Khan, A. G., Catalan, F. V., Perryman, A. L., **Freundlich, J. S.**, Forli, S., Levy, S., Balhorn, R., Azzazy, H. M. E., "Identification of a novel drug lead that inhibits HCV infection and cell-to-cell transmission by targeting the HCV E2 glycoprotein," *PLoS ONE* **2014**, 9, e111333. PMID: 25357246
35. Stec, J., Vilchèze, C., Lun, S., Perryman, A. L., Wang, X., **Freundlich, J. S.**, Bishai, W., Jacobs, Jr., W. R., Kozikowski, A. P., "Biological Evaluation of Potent Triclosan-Derived Inhibitors of the Enoyl-Acyl Carrier Protein Reductase InhA in Drug-sensitive and Drug-resistant Strains of *Mycobacterium tuberculosis*," *ChemMedChem* **2014**, 9, 2528-37. PMID: 25165007
34. Ekins, S., **Freundlich, J. S.**, Reynolds, R. C., "Are Bigger Datasets Better for Machine Learning? Fusing Single-Point and Dual-Event Dose Response Data for *Mycobacterium tuberculosis*," *Journal of Chemical Information and Modeling* **2014**, 54, 2157-65. PMID: 24968215
33. Ekins, S., Nuernberger, E. L., **Freundlich, J. S.**, \* "Minding the Gaps in Tuberculosis Research," *Drug Discovery Today* **2014**, 19, 1279-82. PMID: 24993157
32. Nixon, M. R., Saoinz, K. W., Koo, M.-S., Szymonifka, M. J., Jung, H., Roberts, J. P., Nandakumar, M., Kumar, A., Liao, R., Rustad, T., Sacchettini, J. C., Rhee, K. Y., **Freundlich, J. S.**, Sherman, D. R., "Folate

Pathway Disruption Leads to Critical Disruption of Methionine Derivatives in *Mycobacterium tuberculosis*,” *Chemistry and Biology* **2014**, *21*, 819-30. PMID: 24954008

31. Ekins, S., Pottorf, R., Reynolds, R. C., Williams, A. J., Clark, A. M., **Freundlich, J. S.**,\* “Looking Back To The Future: Predicting In vivo Efficacy of Small Molecules Versus Mycobacterium tuberculosis,” *Journal of Chemical Information and Modeling* **2014**, *54*, 1070-82. PMID: 24665947

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29. Ponder, E. L., **Freundlich, J. S.**, Sarker, M., Ekins, S., “Computational Models For Neglected Diseases: Gaps and Opportunities,” *Pharmaceutical Research*, **2014**, *31*, 271-7. PMID: 23990313

28. Afanador, G.A., Muench, S.P., McPhillie, M., Fomovska, A., Schön, A., Zhou, Y., Cheng, G., Stec, J., **Freundlich, J.S.**, Shieh, H.M., Anderson, J.W., Jacobus, D.P., Fidock, D.A., Kozikowski, A.P., Fishwick C.W., Rice, D.W., Freire, E., McLeod, R., Prigge, S.T., “Discrimination of Potent Inhibitors of Toxoplasma gondii Enoyl-Acyl Carrier Protein Reductase by Thermal Shift Assay.” *Biochemistry* **2013**, *52*, 9155-66. PMID: 24295325

27. Ekins, S., **Freundlich, J. S.**, Reynolds, R. C., “Fusing Dual-Event Datasets for *Mycobacterium tuberculosis* Machine Learning Models and their Evaluation,” *Journal of Chemical Information and Modeling* **2013**, *53*, 3054. PMID: 24144044

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25. Ekins, S., Reynolds, R. C., Franzblau, S. G., Wan, B., **Freundlich, J. S.**, Bunin, B. A., “Enhancing Hit Identification in *Mycobacterium tuberculosis* Drug Discovery Using Validated Dual-Event Bayesian Models,” *PLoS ONE* **2013**, *8*, e63240. PMID: 23667592

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21. Krieger, I. V., **Freundlich, J. S.**, Gawandi, V. B., Roberts, J. P., Gawandi, V. B., Sun, Q., Owen, J. L., Fraile, M. T., Huss, S., Duncan, K., Lavandera, J.-L., Ioerger, T. R., Sacchettini, J. C., “Structure-Guided Discovery of Phenyl-diketo Acids as Potent Inhibitors of *M. tuberculosis* Malate Synthase,” *Chemistry and Biology* **2012**, *19*, 1556.

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19. Vilchèze, C., Baughn, A. D., Tufariello, J., Leung, L., Basler, C., Alland, D., Sacchettini, J. C., **Freundlich, J. S.**, and Jacobs Jr., W. R., “Novel Inhibitors of InhA Efficiently kill *Mycobacterium*

- tuberculosis* under Aerobic and Anaerobic Conditions,” *Antimicrobial Agents and Chemotherapy* **2011**, *55*, 3889.
18. Lotesta, S. D., Yates, E. V., Liu, J., Krieger, I., Sacchetti, J. C., **Freundlich, J. S.**, Sorensen, E. J., “Expanding the pleuromutilin class of antibiotics by *de novo* chemical synthesis,” *Chemical Science* **2011**, *2*, 1258.
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## PATENTS

U.S. Patent Application Serial No. 62/639,352. "Antibacterial Agents: Arylalkylcarboxamido Phloroglucinols."

U.S. Patent Application Serial No. 62/632,761. "Antibacterial benzothiophenes."

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WIPO Application WO 2017/100645 A2, "Inhibitors of Bacterial RNA Polymerase: Arylpropionyl, Arylpropenoyl, and Arylcyclopropanecarboxyl Phloroglucinols."

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U.S. Patent Application Serial No. 60/498,705, "Anti-Cancer Agents and Uses Thereof."

U.S. Patent No. 6,353,076, issued March 5, 2002, "Composition Containing Siloxane Based Polyamides."

U.S. Patent No. 6,051,216, issued April 18, 2000, "Composition Containing Siloxane Based Polyamides."

## CURRENT RESEARCH SUPPORT

Joel S. Freundlich (co-I, 0.12 calendar months), Shumin Tan (PI)

09/18/2019 – 08/31/2024

**R01AI143768** NIH/NIAID

*Mycobacterium tuberculosis* environmental signal integration: single cell *in vivo* understanding of its influence on infection heterogeneity and treatment efficacy

The objective of this grant is to characterize heterogeneity during *Mycobacterium tuberculosis* infections with studies that focus on how this bacterium regulates and integrates its response to multiple ionic

microenvironments, characterization of ionic heterogeneity *in vivo*, and finally how heterogeneity impacts drug susceptibility *in vivo*.

Joel S. Freundlich (PI, 6.0 calendar months), David Perlin (PD) 05/1/2019 – 04/30/2024  
**U19AI142731** NIH/NIAID (\$553,090/yr in direct costs)  
Center to develop therapeutic countermeasures to high-threat bacterial agents  
The objective of this grant is to leverage an array of novel computational, chemical, and biological techniques in the discovery and optimization of small molecular antibacterial agents with significant promise to impact next generation therapeutics.

Joel S. Freundlich (co-I, 0.24 calendar months), Sanjay Jain (PI) 04/01/2019 – 03/31/2020  
**R56AI145435** NIH/NIAID (\$50,000 in direct costs)  
Preclinical modeling to study Tuberculous Meningitis  
The purpose of this project is to use a rabbit model of TB meningitis and *in vivo* imaging to understand the biodistribution of new TB drugs in infected-brain tissues, develop new linezolid and high-dose rifampin based TB treatments and correlate the effect of intracerebral inflammatory responses and antimicrobial exposures with the treatment outcomes in the same animals in ways that are not feasible with current technologies that require resected tissues or necropsies.

Joel S. Freundlich (co-investigator, 1.2 calendar months), David Alland (PI) 03/01/2016 – 02/29/2020  
**R33AI11167** NIH/NIAID (\$107,729/yr in direct costs)  
Discovery and validation of drug targets in vulnerable populations  
The objective of this grant is to evolve chemical probes and drug discovery hits, modulating essential pathways within the bacterial pathogen, to arrive at *in vivo* active antibacterials with defined protein targets.

### COMPLETED RESEARCH SUPPORT

Joel S. Freundlich (PI, 5.6 calendar months), David Perlin (PD) 04/25/2014 – 11/30/2019  
**1U19AI109713** NIH/NIAID (\$640,000/yr in direct costs)  
Center to develop therapeutic countermeasures to high-threat bacterial agents  
The objective of this grant is to leverage an array of novel computational, chemical, and biological techniques in the discovery and optimization of small molecular antibacterial agents with significant promise to impact next generation therapeutics.

Joel S. Freundlich (co-investigator, 0.24 calendar months), Sean Ekins (PI) 09/30/2018 – 09/28/2019  
**W81XWH-17-PRMRP-DA** DOD (\$57,757 in direct costs)  
Novel Inhaled Antibody-Drug Conjugates for treating Tuberculosis  
The objective of this grant to design, synthesize, and biologically profile novel antibody-drug conjugates to treat *Mycobacterium tuberculosis* infection.

Joel S. Freundlich (co-investigator, 1.2 calendar months), Gyanu Lamichhane (PI) 03/01/2016 – 08/31/2019  
**R33AI111739** NIH/NIAID (\$90,000/yr in direct costs)  
Development of oral carbapenem drugs for treatment of drug resistant TB  
The objective of this grant is to leverage knowledge of the inhibition of *M. tuberculosis* L,D-transpeptidases by a diverse class of carbapenems, through biochemical, whole-cell, X-ray crystallographic, and cheminformatic methods, to evolve novel *in vivo* efficacious small molecule antituberculars.

Joel S. Freundlich (PI, 0.6 calendar months), Sean Ekins (co-PI) 02/07/2018 – 07/31/2019  
**R41AI134561** NIH/NIAID (\$47,728/yr in direct costs)  
Structure-guided optimization of an *in vivo* active small molecule antitubercular targeting KasA  
The objective of this grant is to evolve a small molecule antitubercular targeting the essential *M. tuberculosis* gene product KasA to arrive at drug discovery lead candidates.

Joel S. Freundlich (co-PI, 1.2 calendar months) 03/01/17 – 02/28/18  
New Jersey Health Foundation

Developing peripherally acting GABAB receptor agonists for pain control  
The objective of this program is to explore the rational design of small molecule receptor agonists for GABAB.

Joel S. Freundlich (consortium PI, 1.2 calendar months), Sean Ekins (PI) 08/15/2016 – 07/31/2017  
**1R41AI122434** NIH/NIAID

Optimization of small molecule triazine antituberculars for *in vivo* efficacy  
The objective of this grant is to evolve a triazine antitubercular agent to afford an *in vivo* active through computationally aided medicinal chemistry methods while also probing its mechanism of action.

Joel S. Freundlich (co-investigator, 1.65 calendar months), Andrew P. Thomas (PI) 04/16/2012 – 03/31/2017  
**1R01AI099277** NIH/NIAID

Malaria melatonin receptor signaling as a novel drug target  
The objective of this program is to validate a novel antimalarial drug target and mechanism for therapeutic action based on the prior identification of an entirely novel signaling pathway in the malaria parasite.

Joel S. Freundlich (co-investigator, 0.2 calendar months), Paul Dunman (PI) 09/20/2013 – 08/31/2016  
**1R01AI103507-01A1** NIH/NIAID

Development of AK-based assays for antimicrobial screening  
The objective of this program is to develop and leverage a screening platform to identify novel antimicrobial, including antitubercular, small molecules as the starting points for chemical probe and drug discovery.

Joel S. Freundlich (co-investigator, 0.72 calendar months), Sean Ekins (PI) 08/16/2013 – 07/31/2016  
**9R44TR000942-02** NIH/NCATS

Biocomputation across distributed private datasets to enhance drug discovery  
The objective of this program is to harness machine-learning algorithms to construct predictive models for whole-cell efficacy versus *M. tuberculosis* and select ADMET properties and utilize them in the optimization of promising small molecule antituberculars.

Joel S. Freundlich (co-PI, 0.6 calendar months), David Alland (PI) 03/01/2014 – 02/29/2016  
**R21AI111647** NIH/NIAID

Discovery and validation of drug targets in vulnerable pathways of Mtb  
The objective of this grant is to leverage novel *M. tuberculosis* reporter-based screens to identify chemical probes and drug discovery hits that modulate essential pathways within the bacterial pathogen.

Joel S. Freundlich (co-investigator, 0.36 calendar months), Gyanu Lamichhane (PI) 03/01/2014 – 02/29/2016  
**R21AI111739** NIH/NIAID

Development of Oral Carbapenem Drugs for Treatment of Drug Resistant TB  
The objective of this grant is to study the inhibition of *M. tuberculosis* L,D-transpeptidases by a diverse class of both known and novel carbapenems through biochemical, whole-cell, X-ray crystallographic, and cheminformatic methods.

Joel S. Freundlich (co-investigator, 1.32 calendar months), Gyanu Lamichhane (PI) 11/01/2013 – 10/31/2014  
**3DP2OD008459-01S1** NIH/OD

New Drug for Treatment of Chronic Bacterial Infection  
The objective of this administrative supplement is to leverage novel cheminformatics techniques, based on machine learning methodologies, to design potent inhibitors of *M. tuberculosis* L,D-transpeptidases.

Joel S. Freundlich (co-investigator, 0.48 calendar months), Sean Ekins (PI) 4/25/2012 – 4/30/2014  
**2R42AI088893** NIH/NIAID

Identification of novel therapeutic for tuberculosis combining cheminformatics, diverse databases and logic-based pathway analysis  
The objective of this program is to leverage a novel cheminformatics/systems biology software module in the discovery of chemical probes that modulate *in vivo* essential gene products of *M. tuberculosis*.

Joel S. Freundlich (PI) 04/16/2012–03/31/2013

UMDNJ Foundation

Integrative Studies of Fatty Acid Biosynthesis Modulation by Small Molecules: Mechanism of Action and Potency

The objective of this program is to explore the mechanism of action of a novel small molecule antitubercular agent that targets fatty acid biosynthesis.

Joel S. Freundlich (co-PI), Matthew Neiditch (co-PI), David Alland (co-PI) 05/01/2012–04/30/2013

UMDNJ Foundation

The Structure-Based Evolution of *M. tuberculosis* Inhibitors: An Approach Towards a Novel Tuberculosis Therapeutic

The objective of this program is to leverage a structure-based approach to evolve a set of small molecule modulators of a final step in *Mtb* mycolic acid synthesis.

Joel S. Freundlich (co-PI), Andrew P. Thomas (co-PI) 04/16/2012–03/31/2013

UMDNJ Foundation

Malaria Melatonin Receptor Signaling as a Novel Drug Target

The objective of this program is to validate a novel antimalarial drug target and mechanism for therapeutic action based on the prior identification of an entirely novel signaling pathway in the malaria parasite.

Joel S. Freundlich (co-PI) and Erik Sorensen (co-PI) 04/01/2008–03/31/2010

Princeton University Grand Challenges in Global Health

The Integration of Chemistry and Biology in the Classroom and Laboratory to Seed a Next Generation of Scientists, Policy Leaders, and Therapeutics in the Fight Versus Malaria and Tuberculosis

The objective of this program was to discover novel small organic molecules as potential antitubercular and/or antimalarial agents via their structure-based design, synthesis, and biological study of their efficacy and mechanism of action.

#### INVITED LECTURES

American Chemical Society Middle Atlantic Regional Meeting – 05/16/07

U.S./Japan Tuberculosis and Leprosy Annual Meeting – 07/10/08

Johns Hopkins University Department of Medicine – 08/18/08

Texas A&M University Department of Biochemistry and Biophysics – 08/26/08

Princeton University Department of Chemistry – 10/21/08

Rutgers University Department of Medicinal Chemistry – 01/06/09

Global Alliance for Tuberculosis Drug Development – 01/13/09

Rider University – 01/30/09

Wyeth Pharmaceuticals – 06/24/09

Schering-Plough Pharmaceuticals – 06/25/09

Harvard University – 02/04/10

University of Medicine and Dentistry of New Jersey Department of Medicine – 05/05/10

US-Japan TB Meeting – 07/15/10

University of Medicine and Dentistry of New Jersey Department of Pharmacology – 10/11/10

Boston University Department of Chemistry – 12/02/10

NIAID/NBIB Science of Microbial Markers in Tuberculosis (SMMarT) – 6/27/11

Columbia University Workshop on Microbial and Host Diagnostics and Discovery – 4/2/12

University of Medicine and Dentistry of New Jersey Dept. of Microbiology & Molecular Genetics – 9/11/12

Gordon Research Conference on TB Drug Discovery – 07/23/13

Global Alliance for Tuberculosis Drug Development – 12/4/13

Rutgers University Department of Chemistry – 12/6/13

Rutgers University Department of Biochemistry and Molecular Biology – 1/9/14

Johns Hopkins University Department of Pharmacology and Molecular Sciences – 1/29/14

Cornell University Department of Chemical and Biomolecular Engineering – 2/3/14

ACS National Meeting Symposium on “Tuberculosis: Biology and Emerging Therapeutics” – 3/17/14

Stony Brook University Tuberculosis Symposium – 9/22/14

UMass Medical School Department of Biochemistry & Molecular Pharmacology – 10/8/14

Princeton University Department of Chemical and Biological Engineering – 11/23/14  
UNC-Chapel Hill School of Pharmacy – 12/3/14  
Rutgers University Camden Center for Computational and Integrative Biology – 2/3/15  
Rutgers University Newark Department of Chemistry – 2/5/15  
University of Rochester Medical School Department of Microbiology & Immunology – 2/27/15  
World TB Day Conference of TB Biology at the Wadsworth Center – 3/23/15  
ACS National Meeting BIOL Young Investigator Symposium – 08/16/15  
Duke University Department of Chemistry – 12/1/15  
Rutgers University Center for Integrative Proteomics Research – 12/9/15  
St. Jude Children’s Research Hospital Department of Chemical Biology and Therapeutics – 1/7/16  
Temple University Department of Chemistry – 1/28/16  
Princeton University Department of Molecular Biology – 2/19/16  
Boston University Department of Medicine – 2/25/16  
NJMS Global Tuberculosis Institute World TB Day Symposium – 3/22/16  
World TB Day 2016 Symposium – 3/31/16  
Rutgers University Department of Chemistry and Chemical Biology Colloquium – 4/12/16  
Center of Immunity and Inflammation (CII) at Rutgers University – 5/5/16  
University of Maryland Department of Chemistry – 9/15/16  
IBM Corporation New Jersey Town Hall Meeting – 11/4/16  
Michigan State University Department of Biochemistry and Molecular Biology – 2/9/17  
Johns Hopkins Department of Chemistry – 2/23/17  
ACS National Meeting BIOL Chemical Biology of Infectious Disease Symposium – 08/23/17  
Columbia University Department of Microbiology and Immunology – 1/29/18  
Williams College Department of Chemistry – 2/9/18  
Johns Hopkins Department of Medicine – 4/3/18  
New Jersey Institute of Technology Martin Tuchman School of Management – 4/25/18  
ACS National Meeting Medicinal Chemistry Symposium – 08/20/18  
The TB Alliance for Drug Development – 1/3/19  
Princeton University Department of Chemical and Biological Engineering – 3/6/19  
World TB Day 2019 Symposium – 03/25/19  
Princeton University Department of Chemistry – 4/25/19  
AIChE 4th Bioengineering and Translational Medicine Conference (Duke University) – 10/8/19