Final Report: DE-FG02-05ER15647
Applicant/Institution: University of North Texas, Office of Research Services, Denton, TX
Principal Investigators: Kent D. Chapman, (PI); Elison B. Blancaflor (Co-PI)

Title: *N*-Acylethanolamine metabolism and the acquisition of photoautotrophy during seedling establishment

Abstract/ Summary:
Research in our labs, supported since 2005 by Basic Energy Sciences, has led to the discovery of a new lipid mediator pathway that influences phytohormone-mediated regulation of plant growth and development—the so-called *N*-acylethanolamine (NAE) regulatory pathway. This pathway in plants shares conserved metabolic machinery with the endocannabinoid signaling system of vertebrates that regulates a multitude of physiological and behavioral processes in mammals, suggesting that the metabolism of NAEs is an important regulatory feature of eukaryotic biology. Current evidence in plants points to interactions between NAE metabolism, abscisic acid (ABA) signaling and light signaling to modulate seedling establishment and the acquisition of photoautotrophic growth. The proposed research fits well within the mission of Photosynthetic Systems and Physical Biosciences which seek "to understand the processes by which plants, algae and non-medical microbes capture, convert and/or store energy". The fundamental regulatory processes that govern seedling establishment directly influence the assembly of photosynthetic energy conversion systems in essentially all higher plants. Our main hypothesis is that seedlings coordinate the metabolic depletion of NAEs during seedling establishment through a complex interaction of hydrolysis (by fatty acid amide hydrolase, FAAH) and oxidation (by lipoxygenases, LOX) and that newly-reported oxylipin metabolites of polyunsaturated NAEs help to coordinate seedling development and acquisition of photoautotrophy in response to appropriate environmental cues. Evidence suggests that ethanolmide oxylipins derived from NAEs can reversibly accumulate in seedlings and adjust/arrest seedling establishment and chloroplast development in conjunction with ABA signaling and light-signaling pathways. Our results provide important new information linking the production of small molecule lipid mediators in seedlings to the coordinated development of photoautorophy. While relevant to how plants capture, convert and store energy, this work also extends to the general understanding of acylethanolamides and their bioactivity in eukaryotic organisms. In addition, analytical mass spectrometry methodology developed in this work also helped to demonstrate the identification, quantification and spatial localization of NAEs and other lipids in various plant and animal tissues. Cumulative scholarly output includes 45 publications, 2 U.S. Patents, and 24 invited research seminars. This research funding also supported the training of 2 master's students, 4 Ph.D. students and 3 postdoctoral scholars, enhancing the human infrastructure of the U.S. science enterprise.

Publications resulting from the award (40 peer-reviewed journal articles; 1 feature viewpoint, 1 on-line review resource, 5 book chapters, and 2 U.S. Patents issued):

1. **Khan BR, Faure L, Chapman KD, Blancaflor EB** (2017) A chemical genetic screen uncovers a small molecule enhancer of the N-acylethanolamine degrading enzyme, fatty acid amide hydrolase, in Arabidopsis. *Nature Scientific Reports* 2017 Jan 23;7:41121. doi: 10.1038/srep41121.

2. **Sturtevant D, Dueñas ME, Lee YJ, Chapman KD** (2017) Three-dimensional visualization of membrane phospholipid distributions in Arabidopsis thaliana seeds: A spatial perspective of molecular heterogeneity. *Biochim Biophys Acta*. 2017 Feb;1862(2):268-281. doi: 10.1016/j.bbalip.2016.11.012.
3. **Khan BR, Wherritt DJ, Huhman D, Sumner LW, Chapman KD, Blancaflor EB** (2016) Malonylation of Glucosylated N-Lauroylethanolamine: A NEW PATHWAY THAT DETERMINES N-ACYLETHANOLAMINE METABOLIC FATE IN PLANTS. *J Biol Chem*. 30;291(53): 27112-27121. doi: 10.1074/jbc.M116.751065.
4. **Montgomery CL, Keereetaweep J, Johnson HM, Grillo SL, Chapman KD, Koulen P.** (2016) Changes in Retinal N-Acylethanolamines and their Oxylipin Derivatives During the Development of Visual Impairment in a Mouse Model for Glaucoma. *Lipids.* 2016 Jul;51(7):857-66. doi: 10.1007/s11745-016-4161-x.
5. **Sturtevant D, Lee YJ, Chapman KD** (2016) Matrix assisted laser desorption/ionization-mass spectrometry imaging (MALDI-MSI) for direct visualization of plant metabolites in situ. *Curr Opin in Biotech* 37:53-60. doi: 10.1016/j.copbio.2015.10.004. Review.
6. **Hamilton JS, EL Gorishek, PM Mach, D Sturtevant, ML Ladage, N Suzuki, PA Padilla, R Mittler, KD Chapman, GF Verbeck** (2016) Evaluation of a custom single Peltier-cooled ablation cell for elemental imaging of biological samples in laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS). *JAAS (J Anal Atomic Spect)* 31 (4), 1030-1033. DOI 10.1039/C5JA00433K
7. **Montgomery CL, Keereetaweep J, Johnson HM, Grillo SL, Chapman KD, Koulen P** (2016) Changes in retinal *N*-acylethanolamines and their oxylipin derivatives during the development of visual impairment in a mouse model for glaucoma. *Lipids* Jul;51(7):857-66. doi: 10.1007/s11745-016-4161-x.
8. **Pathak S, Kumar KR, Kanta H, Carr-Johnson F, Han J, Bashmakov A, Faure L, Ding H, Vanarsa K, Khan S, Li QZ, Chapman K(D), Wakeland EK, Mohan C.** (2016) Fatty Acid Amide Hydrolase Regulates Peripheral B Cell Receptor Revision, Polyreactivity, and B1 Cells in Lupus. *J Immunol* Feb 15;196(4):1507-16. doi: 10.4049/jimmunol.1500291.
9. **Keereetaweep, J. and Chapman, K.D.** (2016) Lipidomic Analysis of Endocannabinoid Signaling: Targeted Metabolite Identification and Quantification. *Neural Plasticity*, vol. 2016, Article ID 2426398, 13 pages, 2016. doi:10.1155/2016/2426398. In Special Issue on Endocannabinoids. http://www.hindawi.com/journals/np/2016/2426398/
10. **Faure L, Cavazos R, Khan BR, Petros RA, Koulen P, Blancaflor EB, Chapman KD** (2015) Effects of synthetic alkamides on Arabidopsis fatty acid amide hydrolase activity and plant development. *Phytochem*, 110:58-71. doi:10.1016/j.phytochem.2014.11.011. PMID: 25491532.
11. **Keereetaweep J, Blancaflor EB, Hornung E, Feussner I, Chapman KD** (2015) Lipoxygenase derived 9-hydro(pero)xides of linoleoylethanolamide interact with ABA signaling to arrest root development during Arabidopsis seedling establishment. *Plant J* 82(2):315-27. doi: 10.1111/tpj.12821.
12. **Phelps MS, Sturtevant D, Chapman KD, Verbeck GF** (2015) Nanomanipulation-Coupled Matrix-Assisted Laser Desorption/ Ionization-Direct Organelle Mass Spectrometry: A Technique for the Detailed Analysis of Single Organelles. *J Am Soc Mass Spect (JASMS)* 27(2):187-93. [Epub ahead of print] PMID: 26238327. **Cover**

13. **Blancaflor EB, Kilaru A, Keereetaweep J, Khan BR, Faure L, Chapman KD.** (2014) *N*-Acylethanolamines: lipid metabolites with functions in plant growth and development. *Plant J* 79(4):568-83. doi: 10.1111/tpj.12427, early view on line. **Review,** peer reviewed- ***Special issue on Small Molecules in Signaling-- Selected as part of Cover**
14. **Horn PJ, Chapman KD** (2014) Lipidomics *in situ*: Insights into Plant Lipid Metabolism from High Resolution Spatial Maps of Metabolites. *Prog Lipid Res*, 54:32-52. doi: 10.1016/j.plipres.2014.01.003. review.
15. **Faure L, Nagarajan S, Hwang H, Montgomery CL, Khan BR, John G, Koulen P, Blancaflor EB, Chapman KD** (2014) Synthesis of phenoxyacyl-ethanolamides and their effects on fatty acid amide hydrolase activity. *J Biol Chem* 289(13):9340-51. doi: 10.1074/jbc.M113.533315.
16. **Grillo SL, Keereetaweep J, Grillo MA, Chapman KD, Koulen P** (2013). *N*-Palmitoylethanolamine depot injection increased its tissue levels and those of other acylethanolamide lipids. *Drug Design Devel Ther* 7:747-52. doi: 10.2147/DDDT.S48324. PMID:23976843.
17. **Keereetaweep K, Blancaflor EB, Hornung E, Feussner I, Chapman KD** (2013) Ethanolamide oxylipins of linolenic acid can negatively regulate Arabidopsis seedling development. *Plant Cell*, 25(10):3824-40.***Featured In-Brief article in same issue.**
18. **Teaster ND, Keereetaweep J, Kilaru A, Wang YS, Tang Y, Tran CN, Ayre BG, Chapman KD, Blancaflor EB** (2012) Overexpression of Fatty Acid Amide Hydrolase Induces Early Flowering in Arabidopsis thaliana. *Front Plant Sci,* 3:32. Epub 2012 Feb 20., PMID:22645580. ***Special Issue in Lipid Signaling**
19. **Horn PJ, Joshi U, Behrendt AK, Chapman KD, Verbeck GF.** (2012) On-stage liquid-phase lipid microextraction coupled to nanospray mass spectrometry for detailed, nano-scale lipid analysis. *Rapid Comm Mass Spec,* 2012 Apr 30; 26(8):957-62.
20. **Kilaru A, Tamura P, Isaac G, Welti R, Venables BJ, Seier E, Chapman KD**. (2012) Lipidomic analysis of *N*-acylphosphatidylethanolamine molecular species in Arabidopsis suggests feedback regulation by *N*-acylethanolamines. *Planta* 236(3): 809-824. PMID:22673881.
21. **Kilaru A, Chapman, KD** (2012) *N*-Acylated phospholipid metabolism and seedling growth: insights from lipidomics studies in Arabidopsis. *Plant Signal Behav,* Addendum, Sept 1, 7(9).
22. **Garg P, Duncan RS, Kaja S, Zabaneh A, Chapman KD, Koulen P** (2011) Lauroylethanolamide and linoleoylethanolamide improve functional outcome in a rodent model for stroke, *Neurosci Lett* 492(3):134-138
23. **Kilaru A, Göebel C, Keereetaweep J, Hornung E, Venables BJ, Feussner I, Chapman KD** (2011) Lipoxygenase-mediated oxidation of polyunsaturated *N*-Acylethanolamines in Arabidopsis. *J Biol Chem,* 286(17):15205-15214.
24. **Cotter MQ, Teaster ND, Blancaflor EB, Chapman KD (2011)** *N*-Acylethanolamine (NAE) inhibits growth in *Arabidopsis thaliana* seedlings via ABI3-dependent and -independent pathways. *Plant Signal Behav* 6(5):671-679.
25. **Duncan RS, Xin H, Goad DL, Chapman KD, Koulen P** (2011) Protection of neurons in the retinal ganglion cell layer against excitotoxicity by the *N*-acylethanolamine, *N*-linoleoylethanolamine. *Clin Ophthal* 5:543-548. **Highly Accessed** (24,735 views and downloads between April 2011-July 2016)
26. **Kim SC, Chapman KD, Blancaflor EB** (2010) Fatty acid lipid mediators in plants. *Plant Sci* 178(5): 411-419.*

27. **Keereetaweep J, Kilaru A, Feussner I, Venables BJ, Chapman KD** (2010) Lauroylethanolamide is a potent competitive inhibitor of lipoxygenase activity. *FEBS Lett* 584(14):3215-22.
28. **Kilaru A, Tamura P, Garg P, Isaac G, Baxter D, Duncan RS, Welti R, Koulen P, Chapman KD, Venables BJ** (2010). Changes in N-acylethanolamine Pathway Related Metabolites in a Rat Model of Cerebral Ischemia/Reperfusion. *J Glycomics and Lipidomics* 1:101.
doi: 10.4172/2153-0637.1000101. http://www.omicsonline.org/2153-0637/2153-0637-1-101.digital/2153-0637-1-101.html
29. **Kilaru A, Isaac G, Tamura P, Baxter D, Duncan SR Venables BJ, Welti R, Koulen P, Chapman KD** (2010) Lipid profiling reveals tissue-specific differences for ethanolamide lipids in mice lacking fatty acid amide hydrolase. *Lipids* 45:863-75.
30. **Lessire R, E Cahoon, K Chapman, J Dyer, P Eastmond and E Heinz** (2009) Highlights of recent progress in plant lipid research. *Plant Physiol Biochem* 47 (6): 443-447. doi:10.1016/j.plaphy.2009.02.010
31. **Kim SC, L Kang, S Nagaraj, EB Blancaflor, KS Mysore, KD Chapman** (2009) Mutations in Arabidopsis fatty acid amide hydrolase reveal that catalytic activity influences growth but not sensitivity to abscisic acid or pathogens. *J Biol Chem*. 284(49):34065-74. doi:10.1074/jbc.M109.059022
32. **Duncan RS, KD Chapman, P Koulen** (2009) The neuroprotective properties of palmitoylethanolamine against oxidative stress in a neuronal cell line. *Molecular Neurodegeneration*: 4:50, doi:10.1186/1750-1326-4-50.
33. **Kang L, Wang YS, Uppalapati SR, Wang K, Tang Y, Vadapalli V, Venables BJ, Chapman KD, Blancaflor EB, Mysore KS.** (2008) Overexpression of a fatty acid amide hydrolase compromises innate immunity in Arabidopsis. *Plant J* 56(2):336-49.
34. **Welti R, Shah J, Li W, Li M, Chen J, Burke JJ, Fauconnier ML, Chapman KD, Chye ML, Wang X** (2007) Plant lipidomics: Discerning biological function by profiling plant complex lipids using mass spectrometry. *Front Biosci,* 12:2494-2506.
35. **Kilaru A, Blancaflor EB, Venables BJ, Tripathy S, Mysore KS, Chapman KD** (2007)The N-acylethanolamine-mediated regulatory pathway in plants. *Chem Biodivers* 4(8):1933-55. Review. Included in special volume on "Endocannabinoids in Nature and Medicine" DM Lambert, Ed.
36. **Teaster ND, Motes CM, Tang Y, Wiant WC, Cotter MQ, Wang YS, Kilaru A, Venables BJ, Hasenstein KH, Gonzalez G, Blancaflor EB, Chapman KD** (2007) N-Acylethanolamine metabolism interacts with abscisic acid signaling in Arabidopsis thaliana seedlings. *Plant Cell* 19(8):2454-69.
37. **Shrestha, R., Kim, S.-C., Dyer, J., Dixon, R.A., Chapman, K.D.** (2006) Plant Fatty Acid (Ethanol) Amide Hydrolases. *Biochim Biophys Acta (BBA)- Molecular and Cell Biology of Lipids,* 1761(3)*:*324-334
38. **Wang Y-S, Shrestha, R., Wiant, W., Venables, B.J., Chapman, KD, Blancaflor, E.B.** (2006) Manipulation of Arabidopsis Fatty Acid (Ethanol) Amide Hydrolase Expression Leads to Plants with Modified Growth Characteristics and Altered Sensitivity to *N*-Acylethanolamines. *Proc Natl Acad Sci USA,* 103(32): 12197-12202.
39. **Venables, B.J., Waggoner, C.A., Chapman, K.D.** (2005) *N*-Acylethanolamines in Selected Legumes. *Phytochem 66:*1913-1918.

40. **Motes, C.M., Pechter, P., Yoo, C.M., Wang, Y.S., Chapman,K.D., Blancaflor, E.B** (2005) Differential effects of two phospholipase D inhibitors, 1-butanol and *N*-acylethanolamine (NAE), on *in vivo* cytoskeletal organization and *Arabidopsis* seedling growth. *Protoplasma,* 226:109-123.
41. **Faure L, Chapman KD** (2012) *N*-Acylphosphatidylethanolamines (NAPEs), N-Acylethanolamides and other Acylamides: Metabolism, Occurrence and Function in Plants. American Oil Chemists Society Lipid Library- On-line review articles in Plant Biochemistry. http://lipidlibrary.aocs.org/plantbio/nape/index.htm.
42. **Chapman KD and Blancaflor EB** (2011) *N*-Acylethanolamine metabolism in plants—a regulatory pathway diverged from endocannabinoid signaling in mammals? *ASBMB Today* January, 2011, pp 34-35. American Society of Biochemistry and Molecular Biology Newsletter-- Featured Lipid News Article.
43. **Kim SC, Faure L, Chapman KD** (2013) Analysis of Fatty Acid Amide Hydrolase (FAAH) Activity in Plants. In T. Munnik and I. Heilmann, eds, Plant Signaling Protocols, Methods Mol Biol. 1009:115-27. doi: 10.1007/978-1-62703-401-2_12.
44. **Chapman KD, Blancaflor EB** (2009) Fatty Acid Amide Hydrolase and the Metabolism of *N*-Acylethanolamine Lipid Mediators in Plants. T. Munnik ed, Plant Lipid Signaling; Plant Cell Monograph Series vol 16, Springer, pp 293-306 DOI 10.1007/978-3-642-03873-0_19.
45. **Kilaru A, Blancaflor EB, Venables BJ, Tripathy S, Mysore KS, Chapman KD** (2009) The N-Acylethanolamine- mediated regulatory pathway in plants. In D. Lambert, ed., Cannabinoids in Nature and Medicine. VHCA, Verlag Helvetica Chemica, Zurich, pp. 365-87.
46. **Blancaflor, E.B. and Chapman, K.D.** (2006) Similarities between endocannabinoid signaling in animal systems and *N*-acylethanolamine metabolism in higher plants. *In* Communication in Plants, F. Baluska, S. Mancuso, and D Volkmann eds., Ch. 14, Springer-Verlag, pp 205-219.
47. **Blancaflor, EB, Motes, CM, Wang, Y-S, Kang, L., Mysore, KS, Chapman, K.D.** (2006) N-Acylethanolamines: Lipid Mediators of Plant Cytoskeletal Organization and Response to Environmental Stress. *In* Biology of Plant-Microbe Interactions, Volume 5, F Sanchez, C Quinto, IM Lopez-Lara, O Geiger, eds. pp163-170.
48. **US Patent #9,474,271**, issued October 25, 2016- METHOD FOR ENHANCING AMIDOHYDROLASE ACTIVITY OF FATTY ACID AMIDE HYDROLASE. John, George (New York, NY); Nagarajan, Subbiah(New York, NY); Chapman, Kent(Denton, TX); Faure, Lionel(Flower Mound, TX); Koulen, Peter (Leawood, KS). Research Foundation of the City University of New York, New York, NY, USA. Filed **January 14, 2014**—Priority Date January 18, 2013, Application #14/761826, Reference US Provisional application serial no. 61754252. Covers agriculature/plant aspects of invention. UNT, CUNY, and UMKC are joint holders.
49. **US Patent #9,849,101**, issued December 26, 2017. METHOD FOR ENHANCING AMIDOHYDROLASE ACTIVITY OF FATTY ACID AMIDE HYDROLASE. John, George (New York, NY); Nagarajan, Subbiah(New York, NY); Chapman, Kent(Denton, TX); Faure, Lionel(Flower Mound, TX); Koulen, Peter (Leawood, KS). Research Foundation of the City University of New York, New York, NY, USA. **Continuation-in-part (USPTO #9,474,271-above patent)**, covers animal/biomedical aspects of invention. UNT, CUNY, and UMKC are joint holders.

Presentations resulting from the award (24 invited seminars and conference presentations):

1. **Occurrence, metabolism and emerging functions of *N*-acylethanolamines in plants**. Midwestern State University, Wichita Falls, TX, February 2005

2. **Occurrence, metabolism and emerging functions of *N*-acylethanolamines in plants**. University of Louisiana Lafayette, February 2005
3. ***N*-Acylethanolamine Metabolism and Seedling Development in Arabidopsis.** International Symposium on Plant Lipid Signaling. Raleigh, NC, Oct 26-30, 2005.
4. **The *N*-Acylethanolamine (NAE) Regulatory Pathway in Plants.** 2006. University of Texas Southwestern Medical Center, Dallas TX, Department of Cell Biology, December 15, 2006
5. **The *N*-Acylethanolamine (NAE) Regulatory Pathway in Plants.** 2007. North Carolina State University, Dept of Plant Biology, February 20, 2007.
6. **The *N*-Acylethanolamine (NAE) Regulatory Pathway in Plants.** 2007. University of Missouri, Department of Biochemistry, November 9, 2007.
7. ***N*-Acylethanolamine Metabolism Regulates Growth and Responses of Plants to Stress.** 2008. The 18th International Plant Lipid Symposium. July 20-26, 2008, Bordeaux, France. Plenary Speaker, Lipid Signaling Session.
8. **Fatty Acid Amide Hydrolase Expression Influences Plant Growth and Susceptibility to Environmental Stresses. 2009**. 4th European Lipid Symposium March 15-18, 2009. Goettingen Germany, Keynote Speaker, Lipid Signaling Session
9. **Lipoxygenase-mediated formation of novel acylethanolamides in plants.** 2009. International Regulatory Oxylipins Conference. June 4-6, 2009. Lausanne, Switzerland, Invited talk.
10. ***N*-Acylethanolamine Metabolism Regulates Growth and Responses of Plants to Stress.** 2009 Donald Danforth Plant Science Center—Seminar Series, Oct 15, 2009.
11. ***N*-Acylethanolamine Metabolism, Fatty Acid Amide Hydrolase and the Regulation of Plant Growth**. 2011. Gordon Research Conference- Plant Lipids: Structure, Metabolism and Function. Jan 30- Feb 4, 2011. Invited Talk in Lipid Signaling Session.
12. **An Arabidopsis Alpha/Beta-Hydrolase-Fold Protein Influences Lipid Homeostasis in Leaves.** 2012. Seminar Series, Washington State University, Institute of Biological Chemistry, Pullman, WA, May 24, 2012. Invited Speaker.
13. **Oxylipin metabolites of the polyunsaturated acylethanolamide, *N*-linolenoylethanolamine, specifically mediate chloroplast disassembly in cotyledons of Arabidopsis seedling**s. 2012. Invited Oral Presentation. International Symposium on Plant Lipids, Seville, Spain, July 8-13, 2012.
14. **Targeted Lipidomics Approaches to Probe Endocannabinoid Pathway Metabolites.** Invited, Special Interest Group Symposium-- Endocannabinoid Signaling in the Retina – From Biochemistry to Disease to Therapy. Annual Meeting of the Association for Research in Vision and Ophthalmology (ARVO), ARVO 2013. Seattle WA, May 8, 2013.
15. **A LOX Metabolite of *N*-Linoleoylethanolamine (NAE 18:2) Negatively Regulates Seedling Development Through an ABA Signaling Pathway**. Invited oral presentation, Lipid Signaling Section, 6th Biannual European Symposium on Plant Lipids, Bordeaux, France, July 9, 2013.
16. **Mapping the Phospholipid Distribution in Three Dimensions in Arabidopsis Seeds.** European Symposium on Plant Lipids. Harpendon, UK, July 5-8, 2015. Invited speaker.
17. **Metabolism and Function of *N*-Acylethanolamines in Seedling Development**. The Phytochemical Society of North America, Invited Symposium Speaker, Urbana- Champaign, IL August 8-12, 2015

18. **Ethanolamide Oxylipins and Abscisic Acid Signaling during Arabidopsis Seedling Development**. The 6th Asian Symposium on Plant Lipids/ Joint with the Singapore International Lipidomics Symposium, Invited Symposium Speaker, Singapore, November 30- December 5, 2015. Presented by Kent Chapman; Co-authors, Jantana Keereetaweep, Elison Blancaflor and Ivo Feussner.
19. **Ethanolamide Oxylipins and Abscisic Acid Signaling During Arabidopsis Seedling Development**. Department of Biological Sciences Seminar Series, Texas Tech University, April 13, 2016, Invited seminar
20. **Structural insights into Arabidopsis fatty acid amide hydrolase.** 22nd International Symposium on Plant Lipids, Goettingen Germany, July 5, 2016; Invited talk.
21. **Structural insights into the biochemical properties of Arabidopsis fatty acid amide hydrolase.** Phytochemical Society of North America, Davis CA, Aug 10, 2016; Invited talk
22. ***N*-Acylethanolamine metabolism and the regulation of seedling development in *Arabidopsis thaliana***. Department of Biochemistry and Biophysics, Texas A&M University, College Station, TX, October 5, 2016. Department Seminar Series.
23. ***N*-Acylethanolamine Metabolism and the Regulation of Seedling Development in Arabidopsis thaliana**. University of Missouri, Department of Biochemistry Seminar Series, March 3, 2017, Invited talk by Kent Chapman
24. ***N*-Acylethanolamine Metabolism and the Regulation of Seedling Development in Arabidopsis thaliana.** 8th European Symposium on Plant Lipids, Malmoe, Sweden, July 3, 2017. Invited Keynote Lecture by KD Chapman.

M.Sc. and Ph.D. Dissertations supported from the award (2 M.Sc. and 4 Ph.D.):

Dr. Neal Teaster *Ph.D. Molecular Biology* ***(May 2009)***
Dissertation: "A regulatory role for N-acylethanolamine metabolism in Arabidopsis thaliana seeds and seedlings" (Research Molecular Biologist; Department of Homeland Security)

Mr. Matthew Cotter *M.Sc. Biochemistry (**August 2010**)*
Thesis: "Interaction of N-Acylethanolamine Metabolism and Abscisic Acid Signaling in Arabidospsis thaliana" (Laboratory Technician; UT Medical Branch, Shiner's Hospital, Galveston, TX)

Dr. Sang-Chul Kim *Ph.D. Biochemistry* ***(May 2011)***
Dissertation: "Functional Characterization of Plant Fatty Acid Amide Hydrolases" (Post-doc with Xuemin "Sam" Wang, Danforth Plant Science Center, St. Louis, MO)

Mr. Gabriel Gonzalez *M.Sc. Molecular Biology (**Dec 2011**)*
Thesis: "Alterations in fatty acid amide hydrolase transcript levels and activity lead to changes in abiotic stress susceptibility in Arabidopsis thanliana"(Research Scientist; Agricen, Inc. Pilot Point, TX

Dr. Jantana Keereetaweep *Ph.D. Biochemistry* ***(Aug 2015)***
Dissertation: "Metabolism and Action of Polyunsaturated N-Acylethanolamines in Arabidopsis thaliana Seedlings" (Post-doc with John Shanklin, Brookhaven National Laboratory, US Department of Energy, Long Island, NY; June 2015)

Dr. Bikash Adhikari *Ph.D. Biochemistry* ***(Dec 2015)***
Dissertation: "Identification and Characterization of an Arabidopsis thaliana Mutant with Tolerance to N-Lauroylethanolamine" (Post-doc with Xiaoqiang Wang, University of North Texas, Denton, November 2015)

Post-doctoral researchers supported by this award (3):

Dr. Aruna Kilaru (2006-2010), currently Associate Professor, East Tennessee State University, Department of Biological Sciences, Johnson City, TN

Dr. Lionel Faure (2010-2015), currently Research Scientist, Texas Woman's University, Department of Biological Sciences, Denton, TX.

Dr. Mina Aziz (2016- present), currently Post-doctoral Research Associate, University of North Texas, Denton, TX