Soft Matter
An emergent area of interdisciplinary research at UofL

1. Project Background

a. Project goals/specific aims: We propose to formally organize an interdisciplinary group of nine core faculty from six departments into a research cluster in the area of Soft Matter Research at UofL. Additional faculty with relevant interests will be made aware of the research focus and recruited to participate in the program. The cluster initially will establish an Interdisciplinary Traineeship program for doctoral students in Soft Matter along the lines of a National Science Foundation IGERT or NRT Traineeship Grant. Each dissertation committee will include soft matter faculty from at least two departments. Undergraduate students also will have the opportunity to participate in the research through existing NSF Research Experiences for Undergraduates (REU) grants and REU-like internships sponsored by the UofL award. In order to develop a unified vision among the UofL soft matter participants a monthly research seminar will be attended by all participating students and faculty. These joint activities initially will be used to refine external proposals for IGERT and/or NRT graduate traineeship awards, as well as to increase the number of collaborative research proposals to Federal agencies. The development of a unified vision and increased collaborative funding will support longer range efforts to secure National Center Funding (e.g. a Materials Research & Engineering Center or “MRSEC” from National Science Foundation.)

b. Current situation and importance to society: Soft Matter Research is the study of deformation, flow, organization and self-assembly of materials that are soft, squishy and easily deformable; e.g., simple liquid solvents, liquid suspensions of small colloidal particles, oil-water suspensions, foams, lipid bilayers (and by extension, cell membranes), solutions of dissolved polymers, liquid crystals, gels and ultra-stretchy “elastomeric” rubbers. In these systems a small number of physical properties (e.g. surface tension, pressure, gravity, viscosity, temperature, entropy), chemical functionality (e.g. charge, hydrophilicity, hydrophobicity, dipole moment) and macromolecular structure (e.g. linear chain polymer, branched polymer, block copolymer, crosslinked gel, micelles) combine in a myriad of different ways to produce many unusual and unexpected material properties and effects. For instance, colloidal solutions have been demonstrated that instantly harden when shot with bullets, providing greater protection than current Kevlar bullet-proof vests; special polymers have been included in motor oils that increase, rather than decrease, the viscosity as the polymer chains break down; microscale roughness texturing has been used to make surfaces much less wetting than even Teflon by most liquids; while gradients in temperature, electrical field or wettability can be used to controllably move liquid droplets over defined paths, and even uphill. Improved understanding of the behavior of soft matter continues to be of great importance to major industrial sectors including personal care products (e.g. Proctor Gamble—for its creams, gels, conditioners, detergents, etc.), the food industry, plastics manufacture, oil and mineral refining. Numerous companies are being spun off with the goal of applying microfluidic devices and systems, devices developed with an understanding of soft matter principles, to various areas in rapid throughput medical testing, cell sorting, pharmaceutical development and bedside testing.

It is also important to recognize that soft matter principles are a central component of biophysical research at all scale sizes, from bacterial and cell biology up to animals, and even trees. For
example, in cells, long microspikes or filopodia, can be produced by actin filaments deforming the cell membrane. However, the stress of the membrane exceeds the buckling limit of the slender filaments. One physical model shows that that the filopodia can resist collapse with as few as two actin filaments, if the straight filaments deform into a helix.\textsuperscript{4} In animals, gecko feet have evolved a dry, non-chemical and reusable adhesive that adheres to vertical walls with a holding force that exceeds the breaking limit of their limbs. Therefore, it is equally remarkable is that the gecko has evolved a way to unstick its foot with negligible force.\textsuperscript{5} Recently several labs have been developing dry adhesives based on the structure of gecko feet.\textsuperscript{5} This is one application of the field of biomimicry, where the study of living systems has been used to uncover many novel strategies for the design of materials and systems.

It is also important to recognize that the meaning of the term “soft matter” is heavily nuanced by Pierre-Gilles de Gennes, who described the field in his 1991 Nobel Prize in Physics address—titled \textit{Soft Matter}.\textsuperscript{7,9} His approaches to finding simple estimates of the behavior of complex materials (e.g. his scaling theories) enabled major progress to be made in the understanding of numerous soft materials and systems. His approaches and philosophies are followed and strongly influence the field to this day.\textsuperscript{9}

In summary, the field of Soft Matter Research involves the development of fundamental understanding and application of the physical and dynamical properties of soft matter. The field is interdisciplinary and involves research that is at the interface of Physics, Chemistry, Biology and Materials Science, and engineering application, especially in Chemical, Mechanical and Biomedical Engineering. The range of application of the principles of soft matter is so broad, that a core focus and expertise at UofL in Soft Matter would be of great value in helping much of the UofL community (especially, the Sciences in A&S, Engineering, and Health Sciences) identify and use relevant soft matter principles in furthering many of its research activities. In the US as a whole, Soft Matter Research is receiving major funding. Of the 23 current National Science Foundation Material Research Science & Engineering Centers (MRSEC) at least 9 (NYU, U. Chicago, Harvard, MIT, Brandeis, U. Colorado, UPenn, UMass Amherst, Research Triangle: Duke/UNC/NCState) predominately focus on Soft Matter Research, and several other MRSECs have at least 1/3 of their activities focused on Soft Matter Research.\textsuperscript{10} Soft Matter Research is rapidly and increasingly being recognized as a major emerging area of national research priority.

\section*{2. Project Scope and Approach}

\textit{a. Project scope}: The project will be organized as an interdisciplinary graduate program in Soft Matter Research, along the lines of an IGERT/NRT traineeship program (also see Sec. 1.a.) This organization will greatly increase sharing and application of relevant knowledge to ongoing studies, which also should stimulate new research studies and collaborations. The breadth of this interdisciplinary field is such that we anticipate that progress research studies that currently might be difficult or slow to one research group could be greatly accelerated and advanced using knowledge, experience and perspective from the other research groups. The nine core faculty (R. Cohn, J. Fried, R. Keynton, R. Wittebort, S. Yanoviak, G. Willing, Y. Lian, S.J. Williams, M. O'Toole) come from the six departments of Electrical, Chemical, Mechanical and Bio-Engineering, Chemistry and Biology. Their soft matter research activities, which is the core subject matter of the project, is summarized below together with existing UofL collaborations on
these studies. (Collaborations with other researchers outside UofL are noted on the attached CVs.)

R. Cohn, Directed self-assembly of nanostructures and nanostructured devices driven by capillary forces and viscoelastic instabilities. Collaboration with Keynton on patterned drawing of nanofibers. R. Keynton, Biomechanical device development including micron scale pumps and nanoscale cell electroporation devices. S. Yanoviak & his Postdoc A. Stark, Biophysical characterization and biomimicry of adhesive properties of ants to natural plant surfaces. Cohn provides advice and specialized instrumental techniques for measuring the adhesive forces. S.J. Williams, Reversible patterning and transport of colloidal particles using combinations of electrical, thermal and optical driving forces. Collaborations include with Willing on characterizing and controlling the stability of colloidal dispersions, and with Cohn on providing nanoelectrode probes for near field trapping and patterning of nanoscale colloids. G. Willing, Measurements and modelling of forces between colloidal particles. J. Fried, Computational modeling of ion channel transport through lipid bilayers, including synthetic ion channels (synthesized by collaborator G. Gokel at U. Missouri St. Louis) that mimic the function of transmembrane proteins. Y. Lian, Computational hydrodynamics, including modeling of surface tension dominated effects, e.g. droplet impacts. R. Wittebort, Experiments and modeling directed at understanding the elastomeric properties of the protein elastin. M. O'Toole, Development and application of stimulus-responsive biomaterials; i.e., materials that can change form and function based on selected stimuli (e.g. pH, light, temperature, etc.) O'Toole provides an especially valuable resource for the core faculty who primarily study the physical aspects of soft matter in that he can identify, locate and, as needed, prepare soft materials with unique and even programmable functional properties.

We note that the UofL environment can encompass an even larger Soft Matter Research enterprise. For instance, we have identified six additional faculty (from Ophthalmology, Chemistry, and Bio-, Mechanical and Electrical Engineering) who work in soft matter topics. Their related soft matter research interests are D. Borchman & M.C. Yappert the biophysics of lipids in tears and the ocular lens, P. Soucy biochemical regulation of tissue cell mechanical properties, R. Bradshaw polymer composites, aging and reliability, C. Harnett electrical pumping and mixing of liquids, S. McNamara thermally driven pumping of fluids and microdevices to measure van der Waals forces. If the project is funded these faculty will be invited to participate in the project and work over the long term towards developing a sustainable program. At other universities, Math and Physics faculty also participate in soft matter research, and these departments at UofL will be presented opportunities for developing collaborations with the Soft Matter faculty.

Project approach: The mechanics of managing the project are described in in Sec. 3. The research scope is described in Sec. 2a. The topic titles viewed in isolation may not sound related to the field of soft matter (as defined in Sec. 1b.) However, an examination of the publications and grants listed in the attached CV's make more clear the connection between the research topics and the field. Broadly speaking, the topics all rely on the underlying physical principles that define the field of Soft Matter. Therefore, by forming a Soft Matter Research cluster at UofL, the group as a whole will become better informed and more adept at recognizing and applying these principles to widely varying problems and in various fields of study.
c. Relationship to the 2020 Plan and the 21st Century University Strategic Mission: The project is designed to encourage interdisciplinary collaboration among faculty who are only just beginning to recognize that their specialized studies fit well under the broader theme of soft matter. Developing this shared understanding will lead to stronger proposals to agencies, opportunities for group projects and center grants, increased numbers of graduate students and undergraduate research participation. Building this core competence will also benefit other research groups throughout the university by providing these groups expertise needed to help them identify relevant soft matter principles and methods. Of particular importance are new approaches and perspectives that soft matter principles can bring to advancing biophysical studies in the Medical and Dental Schools. The group members and their normal funding agencies are committed to recruitment activities from K-12 outreach, undergraduate outreach and identification of graduate students that continue to work to increase diversity, including attraction of more women and minorities into science and engineering, and recruitment of economically disadvantaged students, such as found in many rural and urban areas of Kentucky and the region.

d. Department/program/unit commitments: Nine faculty and one postdoctoral associate (listed in Sec. 2a) will participate in this project with the goal of building a sustainable graduate research program. The funding request (see attached Budget) will be matched 1-for-1, with departmentally provided GTAs, faculty discretionary funds and research funds from grants. Because the focus of the funding is providing graduate education, tuition in the form of candidacy fees will be provided to GRAs who are fully supported by the award from discretionary funds and from grants for GRAs who are only partially supported on external grants.

3. Project Management Timeline and Expected Benefits

a. Description of project management: Robert Cohn will serve as Principal Investigator on this project and will be responsible for budgets, tracking schedule and reporting progress. The nine core faculty listed above will serve on a committee to identify, rank and select new doctoral students for the project. Each faculty member will direct one or two students in a topic on soft matter. To guarantee interdisciplinarity and enhanced collaboration, selection of a student will require that at least one other core faculty member (who is from a different department) serves on that student’s dissertation committee. Dr. Alyssa Stark (who is Steve Yanoviak’s Postdoctoral Research Associate—CV attached) will serve as seminar coordinator. She will schedule, advertise and moderate monthly seminars which are to be attended by all students and core faculty members. The first hour of the seminars are intended primarily for students to report their work. Additional time immediately following the seminars will be used by the core faculty to review progress, as well as to discuss and identify new research and funding opportunities. Stuart Williams will take the lead in identifying and selecting undergraduate research students and in other outreach activities. Joel Fried, who previously was PI on an IGERT grant at University of Cincinnati, will also provide leadership in terms of advising the project on strategies and opportunities for obtaining federally funded traineeship grants. Rob Keynton, is extensively involved in translational research and the funding of translational research, as well as having an intimate knowledge of the research activities throughout the Medical School. He will work to identify and develop collaborative research and commercialization activities in partnership with the Medical School.
b. Project timeline and key milestones: Based on an award start date of 1Aug16
   ~1Jul16: Faculty meet and start identifying doctoral students for project
   24Aug16: Assign first year students to projects and students meet with advisors
   1Oct16 & monthly thereafter: Seminar—1-2 student reports on research progress to entire group
   1Mar17: University wide research colloquium on Soft Matter presented by Soft Matter faculty
   1Aug17: First Annual Report. Add new students as needed
   ~24Oct17: Research!Louisville breakout session on Soft Matter presented by Soft Matter faculty
   ~1Feb18: First submission of IGERT/NRT traineeship proposal
   1Aug18: Second Annual Report. Add new students as needed
   ~1Jan19: If needed resubmit IGER/NRT proposal or begin developing MRSEC proposal
   1Aug19: Final Report

c. Expected outcomes and assessment plan: We will track and report annually on the following items. Numbers in parentheses are current estimates of the total values expected by the end of the three year project:

   - Doctoral students studying soft matter topics (16)
   - Doctoral degrees awarded (6)
   - Peer reviewed journal publications (30)
   - Collaborative grants between core faculty (10 for $4M)
   - NSF IGERT or NRT traineeship award ($3M over 5 years)
   - Undergraduate research experiences (15 summers — 9 from award, 6 from other awards)
   - Additional faculty who study soft matter topics & join the Soft Matter Research Focus (8)
   - Research collaborations established with soft matter groups outside UofL (6)

4. Projected Impact on Society and University’s Mission

   In order to maintain and enhance the reputation of its graduate programs and its research enterprise, it is important for UofL to continue to restructure its research focus and themes. The initiation of a Soft Matter Research Program at UofL is just such a program that can enhance UofL’s research reputation. In fact, given the rapid emergence, recognition and funding for soft matter research at leading US institutions, it is critical that UofL initiates this program at this time. As mentioned above, this program not only will increase research funding and scholarly productivity through increased collaboration among the members, but also by becoming a resource for other faculty and external researchers, agencies and industries who recognize the need for research support in the field of soft matter.

5. Sustainability Plan

   The proposed project is designed to serve as a pilot project for an IGERT/NRT traineeship program. The project will lay the foundation for a successful NSF application for sustaining funding of graduate fellowships in the interdisciplinary topic area of Soft Matter. Individual research projects performed by GRAs who are directed by two or more members will be used to develop applications for regular research proposals to agencies. Success in funding and publication in these activities will be key to successful applications for center funding (e.g. the NSF MRSEC2,10 and DoD MURI12 programs). We also anticipate that as UofL’s recognition of the field of Soft Matter and the Soft Matter research cluster grows, that it will be natural to fill several faculty vacancies with new hires who have complementary expertise in Soft Matter.
APPENDICES

References

1. IGERT/NRT Traineeship [https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=505015]


### Proposal Grant Budget Sheet

**PI name:** Robert W. Cohn  
**Project title:** Soft Matter - An emergent area of interdisciplinary research at UofL  
**Start date:** 8/1/2016  
**End date:** 7/31/2019

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## Proposal Grant Budget Sheet

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Soft Matter - An emergent area of interdisciplinary research at UofL

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- 100% $ 24,642

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- 100% $ 24,642

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- 20% $ 7,700

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**TOTAL**

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#### PI Name: Robert W. Cohn
#### Project title: Soft Matter - An emergent area of interdisciplinary research at UofL

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#### GRA/GTA Student Package: $24,642 (32,000 Stipend & $2,642 Insurance) & $3,894 Costshare (Candidacy Fee)

| GRA (Cohn) | $ 24,642 | 100% | $ 24,642 | $ 24,642 | $ 24,642 | $ 24,642 | $ 24,642 | $ 24,642 | $ 24,642 |
| GRA (Keynton) | $ 24,642 | 100% | $ 24,642 | $ 24,642 | $ 24,642 | $ 24,642 | $ 24,642 | $ 24,642 | $ 24,642 |
| GRA (OToole) | $ 24,642 | 100% | $ 24,642 | $ 24,642 | $ 24,642 | $ 24,642 | $ 24,642 | $ 24,642 | $ 24,642 |
| GRA (Williams) | $ 24,642 | 100% | $ 24,642 | $ 24,642 | $ 24,642 | $ 24,642 | $ 24,642 | $ 24,642 | $ 24,642 |
| GRA (Lan) | $ 24,642 | 100% | $ 24,642 | $ 24,642 | $ 24,642 | $ 24,642 | $ 24,642 | $ 24,642 | $ 24,642 |
| GRA (Fried) | $ 24,642 | 100% | $ 24,642 | $ 24,642 | $ 24,642 | $ 24,642 | $ 24,642 | $ 24,642 | $ 24,642 |
| GRA (Williams) | $ 24,642 | 100% | $ 24,642 | $ 24,642 | $ 24,642 | $ 24,642 | $ 24,642 | $ 24,642 | $ 24,642 |
| GRA (Keynton) | $ 24,642 | 100% | $ 24,642 | $ 24,642 | $ 24,642 | $ 24,642 | $ 24,642 | $ 24,642 | $ 24,642 |
| **TOTALS** | $ 221,778 | | | | | | | | |

#### GRA/GTA Costshare Match: $28,536 ($22,000 Stipend & $2,642 Insurance) & $3,894 Costshare (Candidacy Fee)

| GTA (Cohn) | $ 24,642 | 100% | $ 24,642 | $ 24,642 | $ 24,642 | $ 24,642 | $ 24,642 | $ 24,642 | $ 24,642 |
| GTA (Keynton) | $ 24,642 | 100% | $ 24,642 | $ 24,642 | $ 24,642 | $ 24,642 | $ 24,642 | $ 24,642 | $ 24,642 |
| GTA (OToole) | $ 24,642 | 100% | $ 24,642 | $ 24,642 | $ 24,642 | $ 24,642 | $ 24,642 | $ 24,642 | $ 24,642 |
| GTA (Williams) | $ 24,642 | 100% | $ 24,642 | $ 24,642 | $ 24,642 | $ 24,642 | $ 24,642 | $ 24,642 | $ 24,642 |
| GTA (Lan) | $ 24,642 | 100% | $ 24,642 | $ 24,642 | $ 24,642 | $ 24,642 | $ 24,642 | $ 24,642 | $ 24,642 |
| GTA (Fried) | $ 24,642 | 100% | $ 24,642 | $ 24,642 | $ 24,642 | $ 24,642 | $ 24,642 | $ 24,642 | $ 24,642 |
| GTA (Williams) | $ 24,642 | 100% | $ 24,642 | $ 24,642 | $ 24,642 | $ 24,642 | $ 24,642 | $ 24,642 | $ 24,642 |
| GTA (Keynton) | $ 24,642 | 100% | $ 24,642 | $ 24,642 | $ 24,642 | $ 24,642 | $ 24,642 | $ 24,642 | $ 24,642 |
| **TOTALS** | $ 221,778 | | | | | | | | |

#### Undergraduate Student Stipend

| Summer Undergrad Interns (X 3) | $ 15,000 | 100% | $ 15,000 | $ 15,000 | $ 15,000 | $ 15,000 | $ 15,000 | $ 15,000 | $ 15,000 |
| Summer Undergrad Interns (X 3) | $ 12 | 300 hrs | $ 3,600 | $ 3,600 | $ 3,600 | $ 3,600 | $ 3,600 | $ 3,600 | $ 3,600 |
| **TOTALS** | $ 18,600 | | | | | | | | |

#### Undergraduate Fringe

| Summer Undergrad Interns (X 3) | $ 7,650 | 100% | $ 7,650 | $ 7,650 | $ 7,650 | $ 7,650 | $ 7,650 | $ 7,650 | $ 7,650 |
| Undergrad Res. Assist. | $ 1,418 | $ 275 | $ 1,418 | $ 275 | $ 1,418 | $ 275 | $ 1,418 | $ 275 | $ 1,418 |
| **TOTALS** | $ 1,423 | | | | | | | | |

#### Staff Salaries

| Postdoc (Keynton) | $ 35,000 | 100% | $ 35,000 | $ 35,000 | $ 35,000 | $ 35,000 | $ 35,000 | $ 35,000 | $ 35,000 |
| **TOTALS** | $ - | | | | | | | | |

#### Staff Fringe

| Postdoc (Keynton) | $ 5,000 | 100% | $ 5,000 | $ 5,000 | $ 5,000 | $ 5,000 | $ 5,000 | $ 5,000 | $ 5,000 |
| **TOTALS** | $ - | | | | | | | | |

#### Supplies, laboratory and other services

| HNCF Service fee (1 ea. For Drs. Cohn, Yanoviak, Williams, O'Toole, Keynton) | $ 7,500 | | | | | | | | |
| Repair & maintenance | $ 600 | | | | | | | | |
| **TOTALS** | $ 8,199 | | | | | | | | |

#### Other expenses

| Year 3 | $ - | | | | | | | | |
| **TOTALS** | $ - | | | | | | | | |

#### DETAILED BUDGET TOTALS

| Year 3 | $ 250,000 | | | | | | | | |
| **TOTAL** | $ 250,000 | | | | | | | | |
BUDGET EXPLANATION
(8/1/16-7/31/19)

This project will fully support 16 PhD level graduate students over the 3 years of the project, together with several undergraduate research assistants and interns, and some partial support for essential postdoctoral support. While not counted towards a match, we will include in our annual report other undergraduate student experiences in soft matter, including at the REU internships assigned to Cohn and Williams in a new NSF REU grant (KM Walsh, PI).

Special note: We have modified the iRFP excel spreadsheet so that each GRA or GTA package has a single line on the sheet. This is to say that a “package” is valued at $28,536, which consists of $22,000 stipend, $2,642 insurance, $3,894 candidacy fees (with the candidacy/tuition fees appearing in the cost share column.) This makes it easier to see which participant is receiving GRA support and how his cost share is being provided. This is also explained further in the budget section Fully Supported Graduate Students.

Request

GRA Support: The request supports up to 1 GRA per faculty member for a total of 8-9 GRAs per year. The requested costs are $22,000 stipend and $2,642 insurance (with $3,894 in candidacy covered by match). In YR1 there are 8 GRAs, in YR2 there are 8.5 GRAs and in YR3 there are 9 GRAs.

Postdoc Support: Dr. Alyssa Stark, who has an interdisciplinary PhD in biology and soft matter (primarily polymer physics) will both support the project in terms of scheduling, organizing and leading the monthly seminar, and she will continue her main research topic of characterizing and understanding adhesion of canopy ants. She will continue as a postdoc at UofL at least 18 months into the award. The remainder of her support is provided by the endowment of her mentor Prof. Yanoviak. A small portion of his support of her may be counted towards a match in YR2 of the project (see Cost Share).

Undergraduate Research Experiences: Undergraduate students will be supported as assistants on an hourly basis and as summer interns. The hourly rate will be $12/hr plus 7.65% fringe. A summer internship will be $5,000 plus 7.65% fringe and we expect to identify and fund 3 student interns. We have budgeted 300 hours of part-time undergraduate research assistance, as well.

Supplies and services: Approximately $9,500 is requested per year in this category. The major cost is $7,500/yr for annual access fees to the Huson Nanotechnology Core Facility (HNCF). HNCF is a University-approved Service Center. Its approved rate is $1,500/yr per faculty member. The fee provides up to two students or postdocs unlimited access to all instruments in HNCF at no additional charge. The key instruments in the service center are two electron microscopes, several atomic force microscopes, including a dual fluorescent microscope and AFM (referred to as a Bio-AFM), a high resolution spectroscopic ellipsometer (Woolam VASE), an extensional rheometer (CABRE) and an extensive set of sample preparation and cleaning tools. A Full-time PhD level staff member is assigned to HNCF to provide training, advice and instrument maintenance. The five faculty members (Cohn, O’Toole, Williams, Keynton and Yanoviak) plan to use these facilities for this project. An additional amount is requested
averaging approximately $2,000/yr to help cover and expedite unexpected repair and maintenance of equipment used on the project. These funds can be requested by any of the participating faculty members.

**Cost Share**

*Candidacy Fees:* These tuition fees are applied to the requested GRAs, who are in candidacy. Candidacy fees are equivalent to the number of student years requested (8, 8.5, 9 in YRS1, 2, 3, respectively.)

*Fully Supported Graduate Students:* Seven to eight graduate students (8 YR1, 7.5 YR2, 7 YR3) will be fully supported as a cost share. For accounting purposes a GTA or GRA is being counted towards cost share as $28,536 ($22,000 stipend, $2,642 insurance, $3,894 candidacy fees), even though prior to candidacy the departmental GTA does automatically cover full-time tuition. In Year 1 there are 5 departmental GTAs, 2 GRAs on grants and 1 GRA from an endowment. In Year 2 there are 4.5 GTAs, 2 GRAs on grants and 1 GRA from an endowment. In Year 3 there are 5 GTAs, 1 GRA from a grant and 1 GRA from an endowment. (Note that whenever possible we will use new grants to release GTA positions back to the departments. Also see Overmatch and Budget Priorities)

*Postdoc Support:* In Year 2, a small fraction of postdoctoral support is required from cost share to reach a one-to-one match. In Year 3, funding of postdoc is needed to meet the cost share. We reserve the right to rebudget these funds towards partial support of a GRA as the specific situation demands.

*Overmatch and Budget Priorities:* While we have described a one-to-one match, in fact the value of the cost share is considerably larger, based on likely additional tuition provided to the GTAs, future University Fellowship students assigned to the participants on this project, additional endowment funds that currently support soft matter research, and current, and possible, future awards in this topic area. Some of these funds may be used to cover unexpected contingencies, as needed.

*Similar to the approach to and philosophy of University Fellowships, the Departments usually guarantee the later years with a GTA position, but with the expectation that the faculty mentor for the student will fund the student from grants whenever possible.*
Robert W. Cohn, PhD
Department of Electrical and Computer Engineering
University of Louisville

Role in relation to this proposed project: Principal Investigator, Direction of his assigned GRAs

Expertise in relation to this proposed project: Professor Cohn has published over 65 papers in refereed journals, has been awarded 8 patents and has served as Principal Investigator on over 40 grants or contracts. He has an extensive record of research, teaching and service in interdisciplinary topics or electrooptics, nanotechnology and, since around 2003, soft matter. Beyond his individual research activities, described below, he has demonstrated his commitment to the broader area of soft matter, through on and off campus promotion and organization of soft matter conferences and workshops, as well as spending a sabbatical year at one of the leading soft matter institutes in the world. His first activity in soft matter is his development (1999-2005) of a multi-trap laser optical tweezers in which multiple microscopic particles in liquid are independently manipulated by computer controlled laser beam patterns. His active involvement in the field began around 2003 when he began his studies to identify and develop methods that use capillary forces to drive self-assembly from liquid precursors, which led to methods form delicately suspended fibers on top of microdevices. Because these structures are very low in stiffness, he has investigated ways to use these to measure ultra-low piconewton-level forces, forces which are in the range of protein motors, bacterial flagellum and lamellipodia protrusion. These soft and flexible structures have also been used as custom probes in atomic force microscopes (AFM), which have enabled very clear AFM measurements of capillary force, surface tension, viscosity and evaporation rate of various liquids. Cohn also provides extensive expertise and infrastructure to the project by providing the project team access to advanced instrumentation and expertise in nanomeasurements and nanofabrication techniques through the Huson Nanotechnology Core Facility (HNCF), a University service center. HNCF includes electron, atomic and optical microscopes, together with various force, electronic and optical nanomanipulators and probes that can be used inside these microscopes to provide extensive in situ probing capabilities that support real-time interactive studies of soft materials and structures.

PROFESSIONAL PREPARATION
University of Kansas English B.A. 1975
University of Kansas Electrical Engineering B.S. 1978
University of Kansas Electrical Engineering M.S. 1982
Southern Methodist University Electrical Engineering Ph.D. 1988

APPOINTMENTS
2009 Sabbatical with Soft Matter Division, ESPCI, Paris, France, Sponsored by D. Quéré
1999-pres. Fellow, Optical Society of America
1998-pres. Director Huson Nanotechnology Core Facility, University of Louisville
1996-pres. Director ElectroOptics Research Institute & Nanotechnology Center, Univ. of Louisville
1995-pres. Professor, Electrical & Computer Engineering, University of Louisville
1989-1995 Associate Professor, Electrical Engineering, University of Louisville
1978-1989 Member of Technical Staff, Texas Instruments, Inc., Dallas, Texas

RELEVANT SYNERGISTIC ACTIVITIES

Outreach: K-12 student workshop - fabrication of nanostructures by directed self-assembly
**Course Development:** Fundamentals of Polymer MEMS, Nanostructure Self-Assembly I & II


**Commercialization and Technology Transfer:** Co-Founder of nanotech company NaugaNeedles, LLC

**SELECTED COLLABORATIONS IN RELATION TO THIS PROPOSAL**

**J-F Berret,** U. Paris-Diderot, *Makes and provides water-dispersible magnetic nanoparticles and nanorods*

**G. McKinley,** MIT, *Non-Newtonian fluid modeling, viscoelastic instabilities and rheological measurements*

**G. N. Tew,** U. Mass. Amherst, *Identification of appropriate polymer functionalities and custom synthesis*


**A. Crosby,** U. Mass. Amherst, *Mechanics of polymer thin films, including confinement effects*

**O. Basaran,** Purdue, *Non-Newtonian fluid modeling of bead-on-a-string formation*

**A. Raman,** Purdue, *Models of hydrodynamic damping of AFM measurements in liquid*

**R. Reifenberger,** *AFM design and measurement techniques, characterization of AFM cantilevers*

**B. Panchapakesan,** WPI, *Photoactuation and programmed 3D shape transformation of nanocomposite elastomers*

**S. Williams,** UofL, *Dielectrophoretic trapping with nanoneedles and flow controlled alignment of nanotube films*

**S. Yanoviak** and **A. Stark,** UofL, *Biologically evolved adhesion, walking, flying of insects*

**S. Atre,** UofL, *Powders and granular materials with application to custom 3D fabrication*

**SELECTED PUBLICATIONS**

**R. W. Cohn** and **B. Panchapakesan,** “Spatially nonuniform heating and the nonlinear transient response of elastomeric photomechanical actuators,” *Sensors and Actuators A* (submitted 13 October 2015) This paper finds that deviations between the experimentally observed stress transients and the heating transients of stretched soft rubbers can be accurately modeled using the classical thermoelastic effect together with a spatially nonuniform heating profile.


X. Fan, B. King, J. Loomis, E. Campo, J. Hegseth, R. W. Cohn, E. Terentjev and B. Panchapakesan, “Nanotube liquid crystal elastomers: Photomechanical response and flexible energy conversion of layered polymer composites,” *Nanotechnology* 25, 355501 (2014) Nanotubes deposited as a thin film between layers of stretched soft rubber generate much greater stress in response to optical illumination than if the same amount of nanotubes are uniformly dispersed in the rubber. Also, nanotube film with well aligned nanotube, similar to liquid crystals, produce greater stress than if the nanotubes are randomly aligned.

R. W. Cohn, “Freestanding metallic and polymeric nanostructures: Directed self-assembly,” pp. 1450–1474, in *Dekker Encyclopedia of Nanoscience and Nanotechnology,* 3rd ed., E. Lyshevski, ed., CRC Press, New York (2014) Book Chapter: This review describes a philosophy and approaches that capillary forces and viscoelastic instabilities can be used to drive the self assembly of nanostructures, especially of very thin and flexible fiber bridges which when fabricated by traditional top down methods are too delicate to withstand destruction by capillary forces.

N. Wood, A. Wolsiefer, R. W. Cohn and S. Williams, “Dielectrophoretic trapping of nanoparticles with an electrokinetic nanoprobe,” *Electrophoresis* 34, 1922-1931 (2013) Electric fields are enhanced using a slender nano-diameter electrode, which then is used to enable mixing, streaming and dendritic growth from liquid suspensions of nanoparticles.
Elastomer strips that are loaded with graphene are configured with light emitting diodes and position sensor feedback to configurate an XY nanopositioning translation stage.


S. M. Berry, T. J. Roussel, S. D. Cambron, R. W. Cohn and R. S. Keynton, “Fabrication of suspended electrokinetic microchannels from directly-written sacrificial polymer fibers,” Microfluidics and Nanofluidics 13, 451-459 (2012) Custom written polymer fiber bridges are used as sacrificial templates to fabricate an microcapillary with electrodes for electrokinetic pumping of microparticles and fluids.

R. Jalilian, J. Rivera, D. Askari, S. Arva, J. M. Rathfon, R. W. Cohn and M. M. Yazdanpanah, “Towards wafer-scale patterning of freestanding intermetallic nanowires,” Nanotechnology 22, 295601 (2011) A batch fabrication process is demonstrated for the method of growing metal nanoneedles from a liquid melt. Included in the study are approaches to wettability and pinning of the gallium droplet to increase the planar area over which the needles can be grown.

J. M. Rathfon, R. W. Cohn, A. J. Crosby, J. P. Rothstein and G. N. Tew, “Confinement effects on chain entanglement probed via branching lifetime of suspended fibers from melting of free-standing polystyrene ultra-thin films,” Macromolecules 44, 5436–5442 (2011) Thin films of suspended polymer nucleate holes that expand and merge to form fibers. Fiber lifetimes are measured for different thickness films. As film thickness approaches the diameter of a polymer chain, the lifetimes begin to rapidly decrease with decreasing thickness, which corresponds to a decreasing number of interchain entanglements as the material transitions from a three-dimensional to a two-dimensional configuration.


M. M. Yazdanpanah, M. Hosseini, S. Pabba, S. M. Berry, V. V. Dobrokhотов, A. Safir, R. S. Keynton and R. W. Cohn, “Micro-Wilhelmy and related liquid property measurements using constant-diameter
nanoneedle-tipped atomic force microscope probes," *Langmuir* **24**,13753–13764 (2008) Using a specially prepared constant diameter probe time for atomic force microscopes (AFM), it is shown that accurate quantitative measurements can be made of surface tension, viscosity and evaporation rate of various liquids.

V. V. Dobrokhotov, M. M. Yazdanpanah, S. Pabba, A. Safir and R. W. Cohn, “Visual force sensing with flexible nanowire buckling springs.” *Nanotechnology* **19**, 035502 (2008) A stiff material can be very flexible if it in the form of a long slender wire. The flexing of a nanowire is observed inside an electron microscope, and the flexing is used to measure the stiffness of a suspended polymer nanofiber that is in contact with the wire.


**SELECTED GRANTS IN RELATION TO THIS PROPOSAL** (pending, active, completed)

S. P. Yanoviak, R. W. Cohn, D. J. Shultz and A. Stark, “IOS Preliminary Proposal: Footprints in the forest: Functional and ecological components of tropical rainforest ant adhesion to plant surfaces to NSF Biology Division (to be submitted January 2016) I provide my expertise in the design of methods and instrumental techniques to measure adhesive forces produced by ants and ant appendages.


K. M. Walsh (PI) “REU: Hands-on Micro/Nano research experience for undergraduates,” National Science Foundation, $465,448. (in negotiation, 1 May 2016 to 25 August 2019) I provide a soft matter research project to an REU student each summer, as does S. Williams.

K. M. Walsh (PI) “NNCI: The Kentucky multi-scale manufacturing and nano integration node (MMNIN),” National Science Foundation, ECCS-1542164, $ 3,672,164 (10 September 2015 to 9 September 2020) RWC provides HNCF—one of the 8 service centers comprising the UofL-UK node. HNCF provides extensive tools for nanoscale imaging, fabrication and characterization of both soft and hard nanostructures.

R. W. Cohn, “Nanostructured self-assembly and characterization of ultra-low force sensing and disposable nanomechanical sensors,” Kentucky Science and Technology Corporation, $50,000 (1 July 2012 to 30 June 2014) Self assembly of beaded nanofibers from polymer solutions together with the optical detection of bead displacement for measuring piconewton forces.

S. J. Williams and R. W. Cohn, “Dielectrophoretic nanoneedles for trapping and characterization of subcellular entities,” Kentucky Science and Technology Corporation, $80,000. (1 July 2011 to 30 December 2013) Electric fields are enhanced using a slender nano-diameter electrode, which then is used to enable mixing, streaming and dendritic growth from liquid suspensions of nanoparticles.

M. M. Yazdanpanah (NaugaNeedles) and R. W. Cohn (subcontract PI), “SBIR Phase II: Batch fabrication of high aspect ratio metallic AFM probes,” National Science Foundation, IIP-1058576, $882,000, subgrant to UofL $150,000. (1 February 2011 to 31 July 2014) A potentially low cost method of parallel fabrication of patterned arrays of nanoneedles from drops of liquid metals is investigated.

R. W. Cohn, “Lateral and torsional deflections of tethered magnetic nanowires for measuring the viscoelasticity of organelles, cytosol and membranes inside individual live cells,” Clinical and Translational Pilot Grant, University of Louisville, $44,024. (1 July 2010 to 30 June 2011) Flexible nanoneedles are used to evaluate the flexibility and strength of cell membranes while observing the nanoneedles under a light microscope.

R. W. Cohn, “Selectively-stimulated self-assembly of polymer thin films into nanometer-scale air-bridges and suspended membranes,” Kentucky Science and Technology Corporation, $80,000. (1 July 2009 to 31 December 2011) A suspended polymer film is selectively patterned with holes by a laser. Then upon heating the film the holes grow and transform into a desired pattern of microfibers and nanofibers.

R. W. Cohn, R. S. Keynton, G. H. McKinley (MIT) and G. N. Tew (U. Mass Amherst), “NIRT: Directed self-assembly of suspended polymer fibers in the fabrication of three-dimensional nanodevices,” National Science Foundation, ECCS-0506941, $1,319,001. (1 September 2005 to 31 August 2010) Interdisciplinary study on ways to pattern suspended polymer nanofibers and to apply these structures to the development of various devices.


R. W. Cohn, E. J. Podlaha (Louisiana State U.) and K. M. Walsh, “Fabrication of masters for extreme precision nanoimprinting of optical gratings,” National Science Foundation, ECS 0202766, $80,000. (March 2002 to February 2004) Nanopatterning by molding of soft or curable polymers with application to integrated optical filtering.
Joel R. Fried
Department of Chemical Engineering
University of Louisville

Role in relation to this proposed project: Co-PI, Direction of his assigned GRAs, Project advisor on pursuing IGERT-like traineeship awards

Expertise in relation to this proposed project: Professor Fried’s research, publication, editorial activities and teaching cover a broad range of topics in soft matter. He has an extensive knowledge of polymer science and technology, including having written a textbook on the subject, and has served as an editor on noted journals within the field. He currently is computationally modeling ion transport through biomimetic cell membranes which is supporting the synthesis of the polymeric membranes and synthetic ion channeling molecules. His experience as a PI on a long running NSF IGERT graduate traineeship award, up until his departure from University of Cincinnati in 2010, is of particular relevance to the proposed project, which is a pilot project modeled along the lines of an IGERT and its successor program, the National Science Foundation Research Traineeship Program (NRT).

EDUCATION
PhD  Polymer Science and Engineering, University of Massachusetts, Amherst  1976
MS  Polymer Science and Engineering, University of Massachusetts, Amherst  1975
ME  Chemical Engineering, Rensselaer Polytechnic Institute  1972
BS  Chemical Engineering, Rensselaer Polytechnic Institute  1971
BS  Biology, Rensselaer Polytechnic Institute  1968

PROFESSIONAL EMPLOYMENT
University of Louisville
2014–present  Professor and Chair, Chemical Engineering
Florida State University/Florida A&M University
2013-2014  Professor and Chair, Chemical & Biomedical Engineering
University of Dayton
2010–2013  Professor and Wright Brothers Institute Endowed Chair in Nanomaterials
University of Cincinnati
2010  Professor Emeritus of Chemical Engineering (lifetime)
2004–2009  Dual Professor of Genome Science, College of Medicine
1998–2002  Head, Department of Chemical Engineering
1990–2010  Professor of Chemical Engineering
1989–1992  Director of the Polymer Research Center
1983–1990  Associate Professor of Chemical Engineering
1978–1983  Assistant Professor of Chemical Engineering

Industrial Experience
1976–1978  Senior Research Engineer, Corporate Research Staff, Monsanto (St. Louis)
1973  Associate Research Staff, Corporate Research & Development Center, GE

AWARDS, HONORS, AND APPOINTMENTS
Fellow of the American Institute of Chemical Engineers 2015
Tau Beta Pi (Eminent Engineer)  2006
SELECTED COLLABORATIONS IN RELATION TO THIS PROPOSAL

G. Gokel, U. Missouri (St. Louis) Synthesis of hydraphile ion channels for polymer bilayers
J. Smith & X. Cheng, Oakridge National Lab, Simulation of self-assembly of polymer block copolymers

EDITORIAL AND RELATED ACTIVITIES

American Associate Editor, *Computational and Theoretical Polymer Science*, 1993–2001

BOOKS


SELECTED BOOK CHAPTERS AND REPORTS


SELECTED PEER-REVIEWED PUBLICATIONS (Over 150 in all)


**SELECTED TALKS AT NATIONAL/INTERNATIONAL MEETINGS** *(OVER 100 IN ALL)*


**SELECTED GRADUATE & POSTDOCTORAL STUDENTS DIRECTED** *(More than 70 in all)*

Michael Martin, Research Associate 2015–present (M.S., EE, UofL), 2015–present.

**SELECTED GRANTS AND CONTRACTS** *(More than $14M in all)*

eXtreme Digital Request Allocation Committee (NSF Teragrid), 7/1/12– 6/30/13, PI, "Fully Atomic Molecular Dynamics Simulation of Artificial Ion Channel/Transporters in Lipid Bilayers," 400,000 SU on Kraken (NICS Cray XT5) and 50,000 SUs on Backlight (PSC SGI Altix UV).


NSF, "REU Site Program in Membrane Applied Science & Technology" (EEC-Human Resources Development Award #0139438, $355,542) (co-PI; Ron Millard, PI); RET Supplement to Award #0139438 ($20,000) (co-PI; Ron Millard, PI).

NSF REU Site Program in "Membrane Applied Science and Technology" ($292,085) (co-PI; William B. Krantz, PI), 4/1/02–3/31/06.

Ohio Board of Regents ($1,782,538 + 224,200 cost sharing), PI, 1995; "Ohio Molecular Computation and Simulation Network and Center for Computer-Aided Molecular Design."

EPA (CR820302010, $394,562 + $20,766 cost sharing), PI, 1992–96 "Advanced Membrane Systems for Direct Insert Membrane Probe Technology."

The US Department of Education ($412,440 + $412,440 cost sharing), 1987–88 (co-PI, with R. Govind, R. Newrock, T. Ridgeway, and J. Paul); "Acquisition of Special Research Equipment."


**PENDING PROPOSALS**


NASA EPSCoR (co-PI; with PI H. Rathnayake, WKU, & J. Anthony, UK). Pre-proposal: Hybrid solar cells for space solar technology at LILT environments: System design, fabrication, and performance evaluation,” $900K
ROBERT S. KEYNTON  
Department of Bioengineering  
University of Louisville

**Role in relation to this proposed project:** Co-PI, Directs his assigned research students, Advises project members on opportunities for commercialization and translational research

**Expertise in relation to this proposed project:** Professor Keynton’s research focuses on the development of polymeric-based fabrication techniques for the creation of medical devices, micro/nano devices and systems for biological and chemical separation, detection and sensing; tissue engineered scaffolds; drug delivery systems; and, cardiovascular mechanics and fluids. His research encompasses materials science and engineering, experimental and computational microfluidics, experimental fluid mechanics, cardiovascular mechanics and acoustic transducer design and fabrication. Keynton is an experienced and effective mentor of students, postdocs, and junior faculty. The project will leverage his expertise on the identification, characterization and application of soft material and microfluidic principles and methods, the translation of these methods into new technologies, devices and commercializable products. As the founding Chair of the Department of Bioengineering at UofL, Keynton, through his active mentoring of departmental faculty, has facilitated research collaborations between faculty in Bioengineering and the UofL Health Science and Medical Campus which have led to the nearly $60M of research funding. Prof. Keynton has been awarded 6 patents and 12 patents pending which have resulted in the issuance of five licenses. He has founded two companies, and he has secured major federal and foundation funding to help other UofL faculty translate their fundamental research into the commercial sector.

**EDUCATION**
Virginia Tech, Blacksburg, VA  BS  1987  Engr Sci & Mechanics
University of Akron, Akron, OH MS 1990 Biomedical Engineering
University of Akron, Akron, OH PhD 1995 Biomedical Engineering

**PROFESSIONAL APPOINTMENTS**
2009-present  Lutz Endowed Chair of Biomechanical Devices, University of Louisville
2006-2009  University Scholar, Bioengineering, University of Louisville
2006-present  Co-founder, Ultra-Trace Detection, LLC, Louisville, KY
2006-present  Professor, Bioengineering, University of Louisville
2005-present  Chair, Department of Bioengineering, University of Louisville
2005-2006  Associate Professor, Bioengineering, UofL
7/04 to 6/07  Interim Scientific Director & Endowed Chair, Cardiovascular Innovation Institute, UofL
2003-present  Co-founder, Assenti, LLC, Louisville, KY
2003-2005  Director, Bioengineering Program, University of Louisville
2002-2005  Associate Professor, Mechanical Engineering, University of Louisville
1999-2002  Assistant Professor, Mechanical Engineering, University of Louisville
1995-1998  Assistant Professor, Biomedical Engineering, Louisiana Tech University
1995-1998  Faculty Research Associate, Inst. for Micromanufacturing, Louisiana Tech University

**HONORS AND RECOGNITIONS**
Fellow American Institute for Medical & Biological Engineering (AIMBE) 2007
Member Board of Directors, AIMBE (2012-14)
Chair Academic Council, AIMBE (2012-14)
Secretary of the Bioengineering Council of Chairs (2010)
Member of the NIBIB Consortium on Addressing Paralysis through Spinal Stimulation Technologies
Technology Journal Editorial Board
Outstanding Young Scientist Award, Houston Society of Engineering in Medicine & Biology 2001
**SELECTED PUBLICATIONS**


**SELECTED GRANTS IN RELATION TO THIS PROPOSAL** (pending, active, completed)

R. S. Keynton and V. Clouse “University of Louisville Innovation Corps Site (I-Corps Site),” National Science Foundation, $299,998 (3/1/15 – 2/28/18) **Goal:** To integrate and leverage existing commercialization infrastructure and to establish a sustainable program for the discovery and commercialization of STEM innovations and stimulate regional economic development.

P. Bates (PI/PD), D. Miller (PI), R. S. Keynton, J. Chaires, J. Chesney, J. Eaton, K. Palmer, and J. Trent, “ExCITE – Expediting Commercialization, Innovation, Translation, and Entrepreneurship,” $3,000,000 (3/20/15 – 2/28/18) **Goal:** To create a commercialization program at the University of Louisville to increase the success rate and speed with which the results of basic biomedical research are translated into products.

R. S. Keynton, M. S. Slaughter and J.R. Zanewicz, “Coulter Foundation Translational Research Partnership Award,” Wallace H. Coulter Foundation, $3,333,000 (7/1/11-6/30/17) **Goal:** To promote translational research via establishing partnerships between engineers and medical clinicians.

P. A. Soucy, R. S. Keynton, M. O’Toole, J. Eaton “A paradigm-shifting therapy for mitigating cellular and tissue damage in humans exposed to radiation,” NASA EPSCoR, $900,000 (1/13 – 12/15) **Goal:** To create curcumin-filled nanoparticles to activate the mediators responsible for cellular self-repair from radiation-induced DNA damage in astronauts.

and R. W. Cohn, “Diagnosing and mitigating human exposure to radiation using micro/nanotechnology,” NASA, $2,000,000 (9/1/10-8/31/12) Goal: To create a diagnostic tool and countermeasures to assess and mitigate human exposure to radiation.

K. Shaver (PI) incl. R. S. Keynton (mentor to PI and subaward PI), “Low country partnership for biomedical innovation,” National Science Foundation PFI $599,998 (1/1/10–12/31/12) Goal: To enhance the commercialization effectiveness at the Medical University of South Carolina through engaging the entrepreneurial expertise from the College of Charleston.


Stuart J Williams, PhD  
Department of Mechanical Engineering  
University of Louisville

Role in relation to this proposed project: Co-PI, Directs his assigned GRAs on microfluidic and electrokinetic colloid manipulation, Leads effort to select undergraduate research students, Identifies additional outreach activities and opportunities

Expertise in relation to this proposed project: Professor Williams has published over 20 papers in refereed journals on topics in experimental microfluidics with an emphasis on electrokinetic mechanisms for the manipulation of colloidal particles. There are a number of diverse electrokinetic mechanisms, including electrophoresis, dielectrophoresis, electro-osmosis, image forces, Joule heating, etc. that may occur simultaneously, making differentiation and analysis of individual mechanisms challenging. This is especially true for electrokinetic applications towards soft matter and two-phase systems where the composition of the media and particles themselves are more complex. Williams is working to develop experimental techniques and analytical methods to advance the principles and application of microscale electrokinetics. Currently Williams designs experiments which are performed on the International Space Station (ISS) in order to study colloidal interactions in an environment where gravity would otherwise be problematic.

PROFESSIONAL PREPARATION
University of Louisville   Mechanical Engineering   B.S.   2005  
University of Louisville   Mechanical Engineering   M.Eng.   2005  
Purdue University   Mechanical Engineering   Ph.D.   2009

APPOINTMENTS
2010-pres.   Assistant Professor, Mechanical Engineering, University of Louisville  
2009-2010   Lecturer, Mechanical Engineering, University of Louisville  
2007   Visiting Researcher, University of Southampton, Southampton, U.K.

RELEVANT SYNERGISTIC ACTIVITIES
Conference activities:  
Conference organizer: Dielectrophoresis 2014 (inaugural) & Dielectrophoresis 2016  

Outreach:  
Internet and social media: YouTube (“ULmicrofluidics” with 21 videos with over 2,400 views) and Twitter (“@ULmicrofluidics”) accounts to disseminate general knowledge in the area of fluid dynamics and colloidal science; development of www.dielectrophoresis.org, a website dedicated to the public education of microscale electrokinetics  
Media: Recently on “UofL Today with Mark Hebert” radio broadcast on 93.9 FM (Nov. 2015)  
Youth Education: Louisville Regional Science and Engineering Fair: Open to all middle school and high school students in Jefferson County and 13 surrounding counties. Winners will compete at the state and national levels for scholarships, tuition grants, trips, and scientific equipment.

SELECTED COLLABORATIONS IN RELATION TO THIS PROPOSAL
H. Rathnayake, Western Kentucky U., Synthesis of colloidal particles
N.G. Green, U. Southampton, *Electrokinetic manipulation and analysis of colloids*
S. Wereley, Purdue U., *Microfluidics and nanofluidics for particle and droplet manipulation*
B. Khusid, NJIT, *Electrokinetic colloidal self-assembly*
H.-S. Chuang, NCKU Taiwan, *Optoelectrokinetic manipulation of droplets and colloids*
NASA Glenn Research Center

**SELECTED PUBLICATIONS**

The following papers focus on the optically-induced electrokinetic manipulation of fluid and particles or general colloidal manipulation, characterization, and/or sorting. Results show enhanced particle sorting, with more recent publications emphasizing applications in biosensors and sorting.

A Mishra, T Maltais, TM Walter, A Wei, SJ Williams, and ST Wereley, “Trapping and viability of swimming bacteria in an optoelectric trap,” *Lab on a Chip* (submitted)


V Velasco and SJ Williams, “Electrokinetic concentration, patterning, and sorting of colloids with thin film heaters,” *J. Colloid and Interface Science* 394, 598-603 (2013)


A Kumar, SJ Williams, H-S Chuang, NG Green, and ST Wereley, “Hybrid opto-electric manipulation in microfluidics – opportunities and challenges,” *Lab on a Chip* 11, 2135-2148 (2011)


SJ Williams, A Kumar, NG Green, and ST Wereley, “Optically induced electrokinetic concentration and separation of colloids,” *Journal of Micromechanics and Microengineering* 20, 015022 (2010)

SJ Williams, A Kumar, NG Green, and ST Wereley, “A simple, optically induced electrokinetic method to concentrate and pattern nanoparticles,” *Nanoscale* 1, 133-137 (2009)

The following papers demonstrate efficient microfluidic pumping using a combination of electric fields and independent thin-film heaters. Will lead to enhanced microfluidic and nanofluidic pumping without the need for moving parts.


The following paper reflects a current research thrust in impedance analysis of biological cells within a microfluidic sample. Future work will focus on impedance analysis of 2D and 3D biological constructs using electrodes.

V Velasco, M Gruenthal, E Zusstone, JMD Thomas, RS Keynton, RE Berson, and SJ Williams, “An orbital shear platform for in vitro real-time endothelium characterization,” *Biotechnology and Bioengineering* (accepted)

These papers demonstrate three-dimensional dielectrophoretic manipulation and assembly of colloids (microparticles and nanoparticles) using inexpensive relatively inexpensive platforms.


**SELECTED GRANTS IN RELATION TO THIS PROPOSAL** (pending, active, completed)

SJ Williams, “Colloidal dielectric forces within an electric curtain”, NSF Particulate and Multiphase Processes, $316,000 (pending)

SJ Williams, “Particle-electrode hydrodynamics for bead-based immunoassays”, NSF Fluid Dynamics, $297,000 (pending)

SJ Williams and J Hoying, “Impedance spectroscopy of cultured microvascular networks”, Kentucky Science and Engineering Foundation $30,000 (pending)

SJ Williams and S Hendricks, “Isomotive dielectrophoresis for enhanced analyses of cell subpopulations”, NSF Instrument Development for Biological Research

SJ Williams, “Self-assembly of colloids for enhanced solar cells”, UF-16-006, NASA Kentucky Space Grant Consortium, Undergraduate Fellowship (Student: David Bergman), 01/01/2016-12/31/2016, $6,000.

SJ Williams, “Dielectrophoresis in air for autonomous dust manipulation and analysis”, UF-16-005, NASA Kentucky Space Grant Consortium, Undergraduate Fellowship (Student: Daniel Allen), $6,000 (01/01/16-12/31/16)

SJ Williams (Science-PI), S Smith (Managing-PI), GA Willing, H Rathnayake, and J Lumpp, “Influence of Gravity on Electrokinetic and Electrochemical Colloidal Self-Assembly for Future Materials”, NASA EPSCoR $1,050,000 (10/01/14-09/30/18)

SJ Williams, “Microfluidic platform for impedance characterization of endothelial cells under fluid shear stress” University of Louisville, Project Completion Grant, $4,000 (06/01/14-05/31/15)
SJ Williams, “Development of an electrokinetic self-cleaning air filter (ESCAF) to support NASA missions” NASA Kentucky EPSCoR, $20,000 (07/01/14-12/31/15)

SJ Williams and RE Berson, “Impedance analysis of endothelial cells undergoing orbital shear”, Multidisciplinary Research Grant, University of Louisville, $10,000 (01/12-12/12)

SJ Williams and RW Cohn, “Dielectrophoretic nanoneedles for trapping and characterization of sub-cellular entities,” Kentucky Science and Technology Corporation, $80,000 (7/1/11- 12/30/13)
Gerold A Willing
Department of Chemical Engineering
University of Louisville

Role in relation to this proposed project: Co-PI, Directs his assigned research students, Studies directed at the fundamentals of colloidal stability, Serves as a liaison with existing educational and outreach programs within in Speed School and the wider UofL community on soft matter related topics

Expertise in relation to this proposed project: Professor Willing has studied surface interactions in colloidal systems for over 20 years. His has extensively used Atomic Force Microscopy for direct force sensing of these surface interactions. He has also used the AFM in studies on mapping of nanoscale physico-chemical variation across Hep2 cells, nanoscale friction force and adhesion measurements, determination of microscale degradation mechanisms in elastomeric and polymeric materials, and nanoscale lithography. Dr.Willing also studies complex fluids for heat transfer applications, electroactive hydrogels for sensor and physiological applications, materials degradation affecting water quality, and developing sustainable recycling methods for rubber and expanded polystyrene. Currently, Willing is working (in collaboration with Stuart Williams) with Western Kentucky University, Los Alamos National Laboratory and NASA Glenn on experiments being performed under weightless conditions on the International Space Station. These studies are designed to better understand the interaction forces that control crystallization dynamics in colloidal suspension with bimodal distributions of both particle size and charge, with the goal of producing novel crystal structures.

EDUCATION
Ph.D. Chemical Engineering, Auburn University, 2001
B.ChE. Chemical Engineering, University of Wisconsin-Madison, 1993

PROFESSIONAL EMPLOYMENT
University of Louisville
2011-Present  Associate Professor, Chemical Engineering
2010-Present  Associate Chair, Chemical Engineering
2004-2011  Assistant Professor, Chemical Engineering

Argonne National Laboratory
2001-2004  Postdoctoral Appointee, Materials Science Division

University of Sydney
1995  Visiting Graduate Researcher, Chemistry

Auburn University
1993-2001  Graduate Research Assistant, Chemical Engineering

S.C. Johnson Wax, Inc.
1992-1993  Chemical Engineering Co-op

SYNERGISTIC ACTIVITIES
Mentored 6 high school students on science fair projects
One student awarded Finalist, Intel Science Talent Search
Proposal Reviews: NSF, Kentucky NSF EPSCoR, Petroleum Research Fund
Session Chair: AIChE Annual Meeting
SELECTED COLLABORATIONS IN RELATION TO THIS PROPOSAL
S. Seifert, Argonne National Laboratory, X-ray scattering characterization of soft matter systems
S.R. Singh, Alabama State University, Director of NSF NanoBiotechnology Research Center
T.R. Tretter, Education, UofL, Effectiveness of awarded graduate fellowship projects

PEER-REVIEWED PUBLICATIONS


PATENTS

SELECTED GRANTS AND CONTRACTS RELEVANT TO THIS PROPOSAL

GA Willing, “Recycling rubber using a water-based process,” Kentucky Science & Technology Corporation, $74,932 (1/1/16-12/31/16)

SJ Williams (Science-PI), S Smith (Managing-PI), GA Willing, H Rathnayake, and J Lumpp, “Influence of gravity on electrokinetic and electrochemical colloidal self-assembly for future materials”, NASA EPSCoR, NNX14AN28A (14-EPSCoR-0011), 10/01/2014-09/30/2018, $1,050,000

C Rich, J Hadizadeh, GA Willing and T Tretter, “Partnership in retention improvement in mathematics, engineering and sciences,” National Science Foundation, DUE-1068301, $1,997,453 (08/15/11-08/14/16)

MK Sunkara and several Co-PI’s including GA Willing, “Nanoscale materials and architectures for energy conversion and scavenging,” DOE EPSCoR $1,128,000 (07/15/11 - 07/14/14)

GA Willing (Co-PI), “Energy efficiency improvements for household appliances via sorption technologies, Phase 2,” General Electric, $107,085 (1/1/14 - 12/31/14)

GA Willing “Development of a biocompatible polymer device for assisting patients with congestive heart failure,” Kentucky Space Grant Consortium, $47,198 (08/01/08 - 03/31/10)

TL Starr and GL Willing, “Nanofluids for advanced military mobility systems – Coolants, fuels and lubricants,” US Army Tank-Automotive Command, $124,000 (10/01/07 - 09/30/09)

SR Singh (PI) with GA Willing (Sub-contract PI), “Center for nanobiotechnology research at Alabama State University, National Science Foundation CREST, $4,900,000 (Subcontract to UofL $171,042) (9/01/07 - 08/31/12)

TD Rockaway and GA Willing, “Surface to mass ratio effects on elastomer degradation,” American Water Works Association, $74,050 (10/15/06 - 09/30/07)

GA Willing, MK Sunkara and TL Starr, “Photo-catalysts for solar energy and hydrogen production,” KY Rural Energy Consortium, $336,780 (4/01/06 - 09/30/07)

TD Rockaway and GA Willing, “Performance and life expectancy of elastomeric components in contact with potable water,” Water Research Foundation, $482,835 (11/01/03 - 10/14/07)
Yongsheng Lian, PhD  
Department of Mechanical Engineering  
University of Louisville

Role in relation to this proposed project: Co-PI, Directs his assigned student researchers

Expertise in relation to this proposed project: Professor Lian has published over 75 papers in refereed journals and archived conference proceeding. He has served as Principal Investigator on over 20 grants or contracts. He has an extensive record of research, teaching and service in fluids and computational fluid dynamics, and since 2010 in soft matter. He has applied his expertise to study droplet impact on dry and wet surfaces of different characteristics. His recent research activities focus on the droplet behavior on hydrophobic and hydrophilic surfaces. He plans to extend to the study of non-Newtonian fluids such as fluids with nanoparticles and polymers, and in 3D printing.

PROFESSIONAL PREPARATION
1998-1999 M.Phil., Mathematics, Hong Kong Univ. of Science & Technology, Hong Kong, China  
1995-1998 M.S., Applied Mathematics, Chinese Academy of Sciences, Beijing, China  
1991-1995 B.S., Mathematics, ShanDong University, JiNan, China

APPOINTMENTS
2014-present Associate Professor, Mechanical Engineering, University of Louisville  
2008-2014 Assistant Professor, Mechanical Engineering, University of Louisville  
2005-2008 Research Specialist, University of Michigan, Ann Arbor, MI  
2003-2005 Senior Researcher, Ohio Aerospace Institute, Cleveland, OH

RELEVANT SYNERGISTIC ACTIVITIES
Organized meetings on Soft Matter: Invited Sidney Nagel, University of Chicago to give a seminar on drop impact at the Mechanical Engineering Department (2012); Invited Constantine Megaridis, University of Illinois at Chicago to give a seminar on drop behavior on patterned surfaces (2013)

Course Development: Computational Fluid Dynamics


SELECTED COLLABORATIONS IN RELATION TO THIS PROPOSAL
S. Nagel, University of Chicago, Drop impact on dry surfaces  
C. Megaridis, University of Illinois at Chicago, Liquid behavior on hydrophobic and hydrophilic surfaces  
A. Jacobi, University of Illinois at Urbana-Champaign, Condensation on patterned surfaces  
M. Sussman, Florida State University, Multiphase flow simulation  
H. Hu, Iowa State University, Drop impact on hydrophobic and hydrophilic surfaces

SELECTED PUBLICATIONS

dynamic behavior of multiphase flows including soft matters.


**SELECTED GRANTS** (pending, active, completed)

PI “A Fundamental Investigation of Ice Accretion due to Supercooled Large Droplets,” (submitted to NSF). *Investigate the behavior of droplets on dry and wet surfaces after impingement.*


PI, “Computer-Aided Optimal Design of a Microfluidic Coulter Counter,” Intramural Research Incentive Grant, University of Louisville, $10,000, 04/2009-03/2010 (co-PI: Dr. Cindy Harnett)

PI, “Numerical Simulation of a Biologically Inspired Corrugated Wing for Micro Air Vehicles”, Intramural Research Incentive Grant, University of Louisville, $4140, 04/2009-03/2010 (no co-PIs)


PI, “Biologically Inspired Wing Design for Micro Air Vehicles”, Kentucky Science and Engineering Foundation, $80,000, 09/2009 – 08/2011 (co-PI: Dr. Suzanne Smith, University of Kentucky)

Co-PI, “Microfluidic Cell Arrays for High-Throughput Cell Culture”, Kentucky Science and Engineering Foundation, $100,000, 07/2009 –06/2011 (PI: Dr. Palaniappan Sethu)


PI, “Multi-physics Simulation of a Coulter Counter”, National Science Foundation, $5,000, 10/2009 – 08/2010 (no co-PIs)


PI, “Numerical and Experimental Study of a Low Aspect Ratio Pitching Wing for MAV Applications”, NASA EPSCoR, $60,119 (Federal amount: $40,000, Institutional match: $20,119), 05/2011–06/2013 (co-PIs: Dr. Sean Bailey, University of Kentucky)

PI, “Numerical Simulation of Gas Pulsation in a Rotary Compressor”, Hitachi Electrical Application Co., $20,000, 05/2011–06/2013 (no co-PIs)

PI, “Sensitivity Analysis of a Dynamic System with Proper Orthogonal Decomposition”, NASA Kentucky Space Consortium, $53,842 (Federal amount: $26,792, Institutional match: $27,050), 01/2012–07/2013 (no co-PIs)

PI, “Build Strong Collaborative Relationships with NASA in the Area of Aeronautics”, NASA, $4,500, 10/2012–12/2013 (no co-PIs)

PI, “University Student Launch Initiative”, NASA, $15,000 (Federal amount: $10,000, Institutional match: $5,000), 01/2013–12/2013 (no co-PIs)


PI, “Fluid and Structure Interaction Study of the Needle Motion in Common Rail High-Pressure Diesel Fuel Injection System”, Cummins Scanis XPI Manufacturing LLC, $170,848, 09/2013–08/2015 (no co-PIs)

PI, “NASA Student Launch”, NASA, $15,000 (Federal amount: $10,000, Institutional match: $5,000), 01/2015–12/2015 (no co-PIs)
Richard J. Wittebort  
Department of Chemistry  
University of Louisville

Role in relation to this proposed project: Co-PI, Directs his assigned research students

Expertise in relation to this proposed project: Professor Wittebort has published over 61 papers in refereed journals. He has an extensive record of research, teaching and service in areas that bridge physics, chemistry and biology. These include structural biology, physical chemistry, coherent spectroscopy, instrument design and studies of molecular dynamics. His current research is focused on soft matter unique to higher organisms: elastic protein matrices. He has served on numerous review panels for the NIH at major universities including Stanford, the University of Pennsylvania, Yale, Carnegie Melon and the University of California and he has been an advisor to the National Magnet Lab at Florida State University, Los Alamos and the University of Florida. He is a permanent study section member of the American Heart Association. His doctoral students have gone on to high quality industrial and faculty positions at Bausch & Lomb, Kimberly Clark, an intellectual property firm, Vanderbilt, and the University of Seoul. He is recognized for his novel experimental work using Nuclear Magnetic Resonance to study molecular dynamics in a variety of systems varying from liquids to solids.

PROFESSIONAL PREPARATION
Ohio State University    Biochemistry    B.S.               1972
Indiana University   Biochemistry    Ph.D.               1978
Massachusetts Institute of Technology    NIH Fellow    Post-Doc    1978-1980

APPOINTMENTS
1988-present     Professor, Department of Chemistry, University of Louisville
2011-2014     Chairman, Department of Chemistry, University of Louisville
1985-1988     Associate Professor, Department of Chemistry, University of Louisville
1981-1985     Assistant Professor, Department of Chemistry, University of Louisville

SYNERGISTIC ACTIVITIES
Study Section, Cell and Molecular Signaling, American Heart Association 2007-present
Ad Hoc Reviewer, NIH Study Sections 2009-2010

COLLABORATORS AND OTHER AFFILIATIONS
Professor Ronald Koder (CCNY)
Professor Tom Haines (CCNY/Rockefeller U.)
Professor Balaji Panchapakesan (Worcester Polytechnic Institute)
Graduate Advisor and Frank R.N. Gurd and A. Szabo (Indiana University)
Post-Doctoral Sponsor Robert Griffin (MIT)

SELECTED PUBLICATIONS  (out of more than 60)


**SELECTED GRANTS IN RELATION TO THIS PROPOSAL** (only grants as PI are listed)

*Goal: To understand the principles that account for elastin's mechanical properties and to use this knowledge to design new elastomeric materials with properties that can be optimized for a particular use. We are applying a combination of NMR and thermo-mechanics to natural elastin and to expressed polyproteins that mimic elastin's modular structure, (HX)n, where H and X are hydrophobic and cross-link modules.*


Martin G. O’Toole, PhD
Department of Bioengineering
University of Louisville

Role in relation to this proposed project: Co-PI, Directs his assigned research students, Lead advisor on developing novel soft matter materials that help to advance investigations of the participating faculty members

Expertise in relation to this proposed project: Professor O’Toole currently focuses on the application that involve soft, stimuli-responsive and programmable materials, including photopolymerizable biodegradable oxygen barriers to prevent cataracts, gold nanoparticles for diagnostic and therapeutic purposes, and formulation of drug delivery systems to improve the efficacy of drugs. O’Toole has extensive training and experience in air-free and open air synthetic organic and inorganic chemistries, and in spectroscopic analysis and interpretation, including: UV/visible spectroscopy, infrared spectroscopy, electrochemistry, electron paramagnetic resonance spectroscopy, nuclear magnetic resonance spectroscopy, mass spectroscopy, spectro-electrochemistry, and gas chromatography. He also uses various tools and packages of computational chemistry including Gaussian 98/03 and NBO program suites (UNIX and Windows platforms), computer-assisted quantum mechanical calculation analysis using GaussView, NBOView, Molekel, and VMD molecular visualization software packages. He is experienced in both organic and inorganic synthesis including heteroatom containing small molecules and inorganic complexes of biological import.

PROFESSIONAL PREPARATION
University of Louisville, Louisville, KY
BA Chemistry 1998
University of Louisville, Louisville, KY
BA Biology 1999
University of Louisville, Louisville, KY
MS Chemistry 2007
University of Louisville, Louisville, KY
PhD Chemistry 2008
University of Louisville, Louisville, KY
Post-Doctoral Nanomedicine 2009

APPOINTMENTS
2012-Present Asst. Professor, Dept. of Bioengineering, Univ. of Louisville
2011-2012 Post Doctoral Scholar, Bioengineering, University of Louisville
2009-2010 Post Doctoral Associate, Electrical Engineering, University of Louisville
2008-2009 Post Doctoral Associate, Chemical Engineering, University of Louisville

RELEVANT SYNERGISTIC ACTIVITIES

Commercialization and Technology Transfer: Co-Founder of ophthalmologic device company Promisight, Inc.

SELECTED COLLABORATIONS IN RELATION TO THIS PROPOSAL
Shlomit Schaal, UofL, Development and implantation of biogels to prevent cataract formation
Shigeo Tamiya, UofL, Testing of PLGA-Dasatinib formations in porcine animal model
Ramesh Gupta, UofL, Testing of drug loaded implants for preventing cervical cancer
Paula Bates, UofL, Expertise on cancer biology and oligonucleotide targeting agents
Tariq Malik, UofL, Cell and Animal testing of cancer targeted nanoparticles
Sergio Mendes, UofL, Electroactive optical waveguides for biosensing
Patricia Soucy, UofL, Cell and animal testing of drug delivery vehicles
SELECTED PUBLICATIONS

The following papers are on an antioxidant biogel I developed that can help prevent post-vitrectomy cataracts. The gel is coated onto the back of the lens during vitrectomy surgery and as proven efficacious in a swine animal model and in ex-vivo lens studies. The gel design is a combination of polymers and particles that drew heavily upon my experience in these areas.


Schaal S, O'Toole MG, Gobin AS, Tezel TH. Prevention of Vitrectomy Induced Cataracts by Biocompatible Photopolymerizable Injectable Gel. The American Society of Retina Specialists (ASRS), San Diego, CA (2014)

The following papers are on optimizing the synthesis of gold nanoplates and of their use in photo-thermal applications. Through our refinements, we can now conduct high-yield one-pot syntheses of gold nanoplates for biomedical, energy, and materials applications. We have implemented these plates in photo-actuated micromechanical systems. Additionally, I have worked in formulating other types of gold nanoparticles (colloidal gold and gold nanoshells) for biomedical applications. Gold nanoparticles serve as a fluorescence contrast agent in part by modulation of near infrared effects. We have also used them for drug delivery and for improved drug delivery by hyperthermal membrane disruption.


The following papers are in the areas of drug formulation and bio-inorganic synthesis. Specifically I synthesized small inorganic iron and nickel complexes as mimics of enzyme active sites. Through this work we were able to elucidate the underlying electronic structure of the active sites as they relate to ligand binding and sulfur oxygenation behavior.


SELECTED GRANTS IN RELATION TO THIS PROPOSAL (pending, active, completed)

M. G. O’Toole and S. Schaal, “Engineering an end to cataracts,” University of Louisville Coulter Translational Partnership in Bioengineering, $418,000 (7/01/12-12/31/15)

Goal: To develop a photo-polymerizable gel coating for protecting the posterior surface of the crystalline lens from oxygen exposure during vitrectomy surgery.

Specific Aims: 1) To formulate a biocompatible photo-polymerizable oxygen barrier for coating the posterior surface of the crystalline lens. 2) Determine the efficacy of the gel oxygen barrier in ex vivo porcine lenses under conditions that mimic the oxygen exposure levels found in the vitreous cavity post-vitrectomy surgery. 3) Determine the efficacy of the gel oxygen barrier in vivo porcine vitrectomy model.

M. G. O’Toole, R. Gupta, and L. Parker, “Sustained, targeted delivery for treatment of cervical pathologies,” University of Louisville Coulter Translational Partnership in Bioengineering, $150,000 (7/01/13-12/31/15)

Goal: Develop a cervical implant for localized delivery of therapeutics to treat cervical dysplasia.
Specific Aims: 1) Design a bench-top injection molding system for creation of the polymer/drug implant. 2) Determine the drug delivery distribution and toxicity of the drug-loaded implant in a goat cervical model.

S. W. Smith (PI), P. Soucy (Science PI), M. G. O’Toole, “A paradigm-shifting therapy for mitigating cellular and tissue damage in humans exposed to radiation,” NASA EPSCoR $750,000 (1/01/14-12/31/16)

Project Goal: To mitigate the damaging effects of space radiation by developing drug delivery vehicles composed of 1) liposomes, unilamellar phospholipid vesicles; 2) albumin-based nanoparticles; and, 3) chitosan-based nanoparticles for systemic delivery of antioxidants.

Specific Aims: 1) Develop liposome, protein, and polymer nanoparticles for delivery of curcumin, NAC, and NMPG, 2) Determine treatment efficiency with curcumin nanoparticle delivery systems prior to radiation exposure, and 3) Determine post-radiation exposure treatment efficiency with NAC and N-MPG nanoparticle delivery systems.

M. G. O’Toole, “Sustained, targeted delivery for treatment of cervical pathologies,” NIH SBIR Phase I, Subcontract $10,127 (1/01/14-12/31/16)

Project Goal: To develop a cervical implant for localized delivery of therapeutics to treat cervical dysplasia.

Specific Aims: 1) Design a bench-top injection molding system for creation of the polymer/drug implant. 2) Determine the drug delivery distribution and toxicity of the drug-loaded implant in a goat cervical model.

P. Bates, T. Malik, M. G. O’Toole, “Nanomedicines for targeted therapy of diverse cancer types,” Kentucky Science & Engineering Foundation, $150,000 (1/01/15 – 12/31/16)

Goal: To prepare cancer-targeting oligonucleotide-coated gold nanoparticles for IND-submission to the FDA.

Specific Aims: 1) Scale up production of aptamer-coated gold nanoparticles. 2) Confirm efficacy of aptamer-coated gold nanoparticles in cell and mouse models of cancer.

M. G. O’Toole, S. Mendes and J. Ramirez, “Rapid diagnostic test for pneumonia and determination of causative agents,” Jewish Heritage Fund for Excellence, $142,000 (11/01/15-10/31/16)

Project Goal: To develop a rapid, sensitive test for pneumonia diagnosis and determine whether it is caused by a virus or bacteria.

Specific Aims: 1) To integrate a transition metal-modified immune-sandwich assay with a electroactive waveguide detection platform. 2) Determine the accuracy of the diagnostic device against urine and sputum samples from patients with clear cut diagnoses.

M. G. O’Toole, P. Bates, T. Malik, and A. Dragun “Towards improved radiation therapy for triple negative breast cancer,” University of Louisville Coulter Translational Partnership in Bioengineering–$150,000 (7/01/15-6/30/16)

Project Goal: To develop a rapid, sensitive test for pneumonia diagnosis and determine whether it is caused by a virus or bacteria.

Specific Aims: 1) To integrate a transition metal-modified immunosandwich assay with a electro-
active waveguide detection platform. 2) Determine the accuracy of the diagnostic device against urine and sputum samples from patients with clear cut diagnoses.

M. G. O’Toole and S. Schaal, “Engineering an end to cataracts,” Kentucky Science & Engineering Foundation, $30,000 (7/01/15-6/30/16)

**Project Goal:** To develop a photo-polymerizable gel coating for protecting the posterior surface of the crystalline lens from oxygen exposure during vitrectomy surgery.

**Specific Aim:** Determine the efficacy of the gel oxygen barrier in ex vivo porcine lenses under conditions that mimic the oxygen exposure levels found in the vitreous cavity post-vitrectomy surgery.

M. G. O’Toole (co-PI), “Pre-clinical testing of sustained release of dasatinib to prevent the major blinding complications following eye injury,” US Department of Defense (DOD) USAMRAA, DRMRP (DM090475) $1,500,000 (9/1/15-8/31/18)

**Goal:** The objective of the proposal is to develop a sustained release mechanism for dasatinib using poly(lactic-co-glycolic acid) (PLGA) that can be introduced into the eye to prevent PVR. We hypothesize that a single application of dasatinib-incorporated PLGA microparticles (dasatinib-PLGA), capable of sustained release of dasatinib, can prevent PVR.

**Specific Aims:** 1) To produce and characterize dasatinib-PLGA in vitro. 2) To prevent PVR, without any detectable adverse effects on the retina, using dasatinib-PLGA in swine.

M. G. O’Toole (co-PI), “SpheraHance, a cancer-targeted contrast agent for MRI and CT Imaging,” NIH Reach ExCITE Program, University of Louisville (12/1/15-11/31/17)

**Goal:** This will allow us to optimize the design of SpheraHance (particle size, ratio of AS1411:Gd, etc.) using a variety of in vitro and in vivo techniques, plus generate in vivo proof-of-concept data to support that SpheraHance is more effective and equally or more safe than standard MRI and CT contrast agents in a clinically relevant animal model of lung cancer.

**Specific Aims:** 1) To produce and optimize various size GNP with aptamer and Gd. 2) Test efficacy of agents in vitro cancer models. 3) Assess efficacy in a lung cancer xenograft model.

**Patents Related to Soft Matter**

Stephen P. Yanoviak  
Department of Biology  
University of Louisville  

Role in relation to this proposed project: Co-PI, Directs his assigned GRAs and Postdoc

Expertise in relation to this proposed project: Research in the Yanoviak lab is a blend of behavioral, evolutionary, and community ecology. Professor Yanoviak has more than two decades of experience conducting observational and experimental investigations in tropical rainforest canopies. The fundamental goal of this work is to understand the selection pressures shaping the diversity and traits of organisms, especially arthropods, inhabiting the treetops. Recent projects have covered a broad range of topics, such as the role of lightning as an agent of tree mortality, the evolution of flight and other aerial behaviors, and the effects of vines on the diversity of canopy-dwelling ants. In collaboration with Dr. Alyssa Stark, the Yanoviak lab is now exploring the role of tarsal adhesion in the behavior and ecology of arboreal ants. This is a transformative line of interdisciplinary research that is perfectly suited to the Soft Matter Initiative proposed here. For the proposed research, Yanoviak will contribute his working knowledge of the diversity and behavior of ants and other insects, which collectively provide excellent models for adhesion studies. He will contribute biomechanics and functional morphology topics for discussion in the proposed seminar series and will train graduate students in the measurement of ant tarsal adhesion in the field and lab.

PROFESSIONAL PREPARATION  
Auburn University  
Entomology  
B.S.  
1991  
Purdue University  
Entomology  
M.S.  
1993  
University of Oklahoma  
Zoology  
Ph.D. & postdoc  
1999  
Evergreen State College  
Ecology  
postdoc  
1999-2001  
University of Texas  
Vector Ecology  
postdoc  
2001-2007  

APPOINTMENTS  
2014-pres.  
Associate Professor. Department of Biology, University of Louisville.  
2012-pres.  
Tom Wallace Endowed Chair of Conservation, Department of Biology, Univ. Louisville  
2012-14  
Assistant Professor, Department of Biology, University of Louisville  
2007-12  
Assistant Professor, Department of Biology, University of Arkansas-Little Rock  
2007-12  
Adjunct Faculty, Department of Biology, University of Arkansas, Fayetteville  
2001-07  
Visiting Faculty, University of Florida, Florida Medical Entomology Laboratory  

SYNERGISTIC ACTIVITIES  
Teaching and Training: development of special topics course in forest canopy biology, development of Ecology and Organismal Biology curriculum concentration at UALR. La Selva REU program, Costa Rica; Organization for Tropical Studies, Costa Rica and Peru; University of California Education Abroad Program; University of Panama  

Consultant: Smithsonian Institution Monitoring and Assessing Biodiversity (SIMAB) Program; Innovative Vector Control Consortium, Peru; Wadsworth Center, NY; BBC Natural History Unit; FTN Associates, Inc.; Friday, Eldredge & Clark, LLP  

Associate Editor: Insect Diversity and Conservation  

Session Organizer & Moderator: Ecological Society of America, Society for Integrative and Comparative Biology, International Canopy Conference, Entomological Society of America

RECENT PROJECT-RELATED PUBLICATIONS


RECENT PROJECT-RELATED GRANTS

NSF DEB-1354060 "Ecology of lightning in tropical forests" $200,000

NSF DEB-1252614 "CAREER: Overcoming shyness: Lianas determine local ant diversity in the tropical forest canopy" $750,000

NSF IOS-0843120 "Biomechanics and ecology of gliding in arthropods" $252,547

NSF DEB-9975510, "Effects of disturbance on the diversity and functional roles of canopy communities in a tropical montane landscape" (co-PI with N. Nadkarni), $370,117

Franklin Research Award, American Philosophical Society, $6000

National Geographic Society, CRE 8352-07, (co-PI with M. Kaspari), $21,000

National Geographic Society, CRE 7896-05, $20,000

Amazon Conservation Association, "Behavioral ecology of tropical canopy ants", $9000

Huron Mountain Wildlife Foundation "Lightning ecology in a boreal forest" $3200
**Alyssa Y. Stark**  
Department of Biology  
University of Louisville

**Role in relation to this proposed project:** Seminar coordinator, Postdoctoral Researcher

**Expertise in relation to this proposed project:** Dr. Stark is a postdoctoral associate who has published over 13 papers in refereed journals and served as a reviewer for journals such as Proceedings of the National Academy of Sciences, Proceedings of the Royal Society: B, Journal of Experimental Biology, ACS Nano and Bioinspiration & Biomimetics, among others. Much of Dr. Stark's research activities, described below, fall into the category of soft matter, particularly biological soft matter. Most biological materials are viscoelastic, and thus are relevant to the soft matter field. In Dr. Stark's focus on biological adhesives, material and chemical properties are key to understanding how organisms attach and detach in their environment. Particularly unique to Dr. Stark's research is the integration of biology and material science. This supports a broader approach to biological and materials-based questions. In addition, Dr. Stark is directly involved with the use of bio-inspired design to develop synthetic adhesives that mimic the successful designs found in nature. The use of bio-inspired design to ask and answer questions falls into a broader, emerging field called biomimicry. Currently Dr. Stark works with two non-profit organizations that work to integrate biomimicry into industry and educational systems both in the regional and globally.

**PROFESSIONAL PREPARATION**

University of California, Davis   Animal Biology   B.S.   2006  
The University of Akron   Integrated Bioscience   Ph.D.   2014

**APPOINTMENTS**

2014-pres.  Postdoctoral Associate, Department of Biology, U. of Louisville  
2013-2014  Project Manager, Biomimicry Research and Innovation Center, U. of Akron  
2008-2013  Teaching Assistant, Department of Biology, U. of Akron

**RELEVANT SYNERGISTIC ACTIVITIES**


Outreach: 4-day 4th grade science lesson at St. Mathews Elementary School on Biomimicry (2015); Invited speaker to aid Girl Scouts of NE Ohio Cadette Troop #90115 in earning "Animal Helpers Badge" by learning about biomimicry (2014); grade 6-8th demonstration at Our Lady of the Elms School Polymer Family Night (2009)

Course Development: Guest lecturer on biomimicry for Biology for Non-majors (2015) and Conservation Biology (2014 and 2015)


Society Participation:  
Co-chair of Adhesion and Robotics, Annual Adhesion Society Meeting (2016)  
President Bioadhesives Division, Adhesion Society (proposed, to be confirmed 2016)  
Session Moderator Society for Integrative and Comparative Biology (2015)
SELECTED COLLABORATIONS IN RELATION TO THIS PROPOSAL
Cohn, R. W. of Louisville, Biological material visualization and characterization
Brennan, A. U. of Florida, Makes and provides structured material for anti-adhesive purposes
French, R. Case W. R. U., Optical techniques to study quantum electrodynamic interactions
Miyoshi, T. U. of Akron, Solid and liquid-state NMR for analysis of biological samples
Astrop, T. U. of Bath, Geometric morphometric methods and phylogenetic techniques
Wesdemiotis, C. U. of Akron, Mass spectrometry and tandem mass spectrometry
Sitti, M. Max Planck Institute, Makes and provides structured bio-inspired adhesives
Sameoto, D. U. of Alberta, Makes and provides structured bio-inspired adhesives

SELECTED PUBLICATIONS


**SELECTED GRANTS IN RELATION TO THIS PROPOSAL** (pending, active, completed)


**CONSULTING**

Great Lakes Biomimicry, 2013-pres. *I serve as a subject matter expert and advise on the collaboration between industry partners and scientific researchers.*

Biomimicry 3.8 and the Biomimicry Institute, 2015-pres. *I serve as a subject matter expert for the global biomimicry design challenge teams.*
Robert W. Cohn, Ph.D.
Director, ElectroOptics research Institute & Nanotechnology Center
University of Louisville

Dear Dr. Cohn,

It is with great pleasure that I offer support for your submission to the School of Interdisciplinary and Graduate Studies and Office of Research and Innovation: Academic and Research Excellence for the 21st Century University. The proposed project, “Soft Matter: An Emergent Area of Interdisciplinary Research at UofL,” would be a valuable step in advancing a truly multidisciplinary field of research that already cuts across several departments and many research specialties at our university. The research team includes nine faculty members from four departments in the Speed School and two in Arts & Sciences, several of whom have existing collaborative relationships, and some notable researchers from other institutions.

The proposal includes a strategy for bringing additional faculty into the effort. Many of the current topics with a soft matter theme involve biophysics, biomimicry and biomaterials, often with a medically related application. From this trend it is clear that a focus soft matter initiative at UofL could provide major new viewpoints and approaches for Medical School investigators to advance their research.

Additionally, the project, which is modeled along the lines of a doctoral Traineeship (e.g. and NSF IGERT award), directly provides support for at least 16 doctoral students in interdisciplinary research. The students (as well as their faculty mentors) will become much more broadly aware and effective in the many faceted field of soft matter though participation in the monthly seminar series, where students primarily give progress reports on their research studies. Additionally the award would support undergraduate internships. These summer students enjoy the experiences of working alongside the graduate students and faculty, and the experiences often lead to the students deciding to pursue an advanced degree.

Not only is the topic area of Soft Matter an important emerging area of research, but it is one for which there are many interesting, unusual and visually stunning phenomena that can be observed with the naked eye, and thus an area of growing interest to students and the general public. Examples of such visually stunning phenomena are accessible via Amazon.com or Google image search of the book, A Drop Of Water: A Book of Science and Wonder by Walter Wick from Scholastic Press. Other equally stunning results are available among publications of the Soft Matter team, many of which are advancing understanding and extending the many practical applications of Soft Matter.

This soft matter research proposal is an innovative project that should touch several Schools and Colleges within our University and I am glad to support it in both concept and action. On behalf of the College of Arts & Sciences and over the three-year period of this pilot project, I support the pledges from Biology and Chemistry to commit to funding two graduate research assistantships. Arts and Sciences is supportive of this submission and I commit to being involved at a level that will help with implementation of your vision. Together, I am confident that we can exceed expectations.

Cordially,

[Signature]

Dr. Kimberly Kempf-Leonard
Dean
College of Arts and Sciences

University of Louisville • Louisville, KY 40292
Dr. Neville Pinto  
Executive Vice President and University Provost  
University of Louisville  
Louisville, KY 40292

Dear Dr. Pinto,

I am writing in strong support of the enclosed proposal for the UofL 21st Century Initiative entitled: **Soft Matter: An emergent area of interdisciplinary research at UofL.** This proposal assembles an impressive team of nine core faculty (R. Cohn, J. Fried, R. Keynton, R. Wittebort, S. Yanoviak, G. Willing, Y. Lian, S.J. Williams, M. O’Toole) from the six departments of Electrical, Chemical, Mechanical and Bioengineering, Chemistry and Biology. Several of these faculty already have existing collaborations with each other, as well as a number of notable researchers from the field who are at other institutions. The project will be organized as an interdisciplinary graduate program in Soft Matter Research, along the lines of an IGERT/NRT traineeship program, which will increase sharing and application of relevant knowledge to ongoing studies, which also should stimulate additional research studies and collaborations.

A focused soft matter initiative at UofL could provide major new viewpoints and approaches that help numerous investigators to advance their research. The possibilities for increased support of research on the Health Sciences Campus is further expedited by the Speed Bioengineering Department, which was established with a major goal of improving the pipeline of Engineering School technology and expertise to the Medical School.

The project will achieve and enhance many of the 21st Century goals including: stronger proposals to agencies, opportunities for group projects and center grants, increased numbers of graduate students and undergraduate research participation. The project also shows strong commitment to recruitment activities for K-12 outreach, undergraduate outreach, and identification of graduate students that continue to work to increase diversity, including attraction of more women and minorities into science and engineering, and recruitment of economically disadvantaged students in Kentucky and surrounding regions.

As such, I heartily endorse this proposal and will be happy to provide you with any additional information that you might need. Thank you.

Sincerely,

John Usher  
Acting Dean