

**SPECIAL REPORT
OF THE
RESEARCH COUNCIL
concerning
CREATION OF THE CENTER FOR EVOLUTIONARY MATERIALS
IN THE
COLLEGE OF NATURAL SCIENCES
(#6912)**

**Presented at the
807th Regular Meeting of the Faculty Senate
October 14, 2021**

RESEARCH COUNCIL MEMBERSHIP

Dominique Alfandari, Amir Arbabi, MJ Alhabeeb, Ian Barron, Casey Brown, Carey Clouse, E. Bryan Coughlin, Robert DeConto, Jennifer Donais, Lori Goldner, Krista Harper, Michelle Hosp, Sarah Hutton, Paul Katz, Ken Kleinman, James Kitts, Kathryn Lachman, Michael Malone, Anna Nagurney, , Martina Nieswandt, Jennifer Normanly, Anthony Paik, Ashwin Ramasubramaniam, Peter Reinhart, Alexander Ribbe, Brian Shelburne, Hava Siegelman, Laurel Smith-Doerr, Carol Sprague, Kimberly Tremblay, Maria Tymoczko, Rachel Walker, Jacqueline Urla

COUNCIL RECOMMENDATION

The Research Council recommends approval of this proposal.

A subcommittee of the Research Council reviewed the application for permanent status of The Center for Evolutionary Materials (CEM). The CEM Directors Alfred Crosby and Duncan Irschick made a presentation about the Center and its activities to the full Research Council on April 30th. The RC voted to recommend permanent status.

Does the Center contribute to the mission of the campus?

- **The CEM defines itself as a center, which develops a philosophical strategy combining observation of adaptations from nature and evolution with knowledge of physics, chemistry, engineering, materials science, and computational science to**

address materials challenges for societal benefit. The Center facilitates interdisciplinary intellectual interactions, coordinates access to new funding opportunities, has broader impacts with outreach programs, and organizes promotional opportunities.

- The CEM contributes to the mission of the campus in education, research, and improving the lives of the people of the Commonwealth, the nation, and the world. CEM research and education objectives are focused on improving society. They train and mentor future scientists and engineers in methods of evolutionary or bioinspired materials. This skill development is critical for using natural resources in a sustainable manner to inform the solution to global challenges. They also engage regional, state, national, and international scientists and engineers through symposia and seminar series.

Has the Center been successful in meeting its own goals and objectives?

- One of the primary goals of CEM is to engage local communities and to support the development of a pipeline of students, especially in communities with large fractions of their population that are under-represented in STEM fields. This includes working with local schools. CEM supported the development of Bioinspired!, an outreach program developed in collaboration with the Amherst Regional School District to inspire elementary age children through science-based art lessons. In addition, CEM has hosted numerous groups of K-12 students for laboratory tours, demonstrations, discussions, and lectures. These students come from Springfield, Amherst, Northampton, among other western Massachusetts communities.
- Another goal has been to promote social networking and research collaborations among junior researchers, and especially among underrepresented minorities and women. The center has worked to create an inclusive and welcoming environment for both groups, and the ADVANCE mutual mentoring grant was an excellent fit for this goal. They have a 14 women/16 men ratio in membership. We have purposefully/actively planned our events and activities to encourage. CEM has supported an NSF UMass ADVANCE-funded project entitled, CEM³. CEM³ builds upon CEM's connections to industry as well as connections across a wide range of academic disciplines to mentor early career scientists and engineers in ways to access revenue streams they don't normally have access to, including industrial research grants.
- A research goal of CEM is to take inspiration from the remarkable variation among species in form, structure, and material properties to create new "hybrid" materials that take advantage of advantages in different organisms while circumventing key weaknesses. Researchers within CEM have succeed in examining how the same structure in different species enables a higher level of performance in a bioinspired material than might normally be observed within a single species.

Does the Center have adequate financial resources for continued operations?

- Minimal resources are required, but CUMIRP and continued supplements through multi-PI grants, for example the Office of Naval Research Basic Research Challenge

grant, the Army Research Office Multi-University Research Initiative, provide funding for the CEM Program Manager as well other incidental expenses. The overall effort of the CEM Program Manager, Jennifer Green, is adjustable based on the overall grant support. If the overall level of support is somewhat lower, then the other members of the center can attend to the various needs. Therefore, the basic output of the center is not largely impacted by overall levels of grant support. Activities, such as the Bioinspiration Symposium in 2019, CEM requires participants to pay registration costs, which cover the costs of the meeting.

Has the Center effectively leveraged campus resources? External funding secured?

- **External funding:**
 - **2016 UMass President's Office S&T Fund Award (\$125,000)**
 - **a UMass President's Office Creative Economy Fund Award (\$18,686)**
 - **Office of Naval Research Broad Research Call award of \$2,646,990 funding Crosby, Lee, Peyton and Tew.**

Is the user/client/beneficiary community appropriately sized to fulfill its mission?

- **There is an active user community that is appropriately sized. There are over 23 faculty members, 9 departments.**

Are users/clients/beneficiaries getting sufficient value?

The faculty, students, and postdoctoral researchers attend biweekly meetings, and symposia. Many have participated in our outreach activities, and have led or participated in our ADVANCE CEM³ group. CEM members meet with the CEM Program Manager to discuss processes and services that can aid the development of multi-PI proposals related to CEM topics.

PROPOSAL

General Questions

1. Is this proposal for a Center or an Institute?

Center

2. Proposed Title of Institute/Center

Center for Evolutionary Materials (CEM)

3. What is the School/College or other major budgetary unit that this center or institute will be a part of?

College of Natural Sciences

4. What are the names of the Center/Institute directors or other responsible persons ?

Alfred Crosby, Co-Director (PSE)

Duncan Irschick, Co-Director (Biology)

5. What is the mailing address, telephone number of director(s) or responsible persons ?

Conte Building, 120 Governors Dr, UMass, Amherst, 01003

6. What is the proposed starting date?

Immediately

Description

1. Please provide a brief description (60 words or less) of the proposed enterprise (name, basic mission, activity scope, clientele).

A Center to develop a philosophical strategy that combines observation of adaptations from nature and evolution with knowledge of physics, chemistry, engineering, materials science, and computational science to address materials challenges for general societal benefit. The Center will facilitate interdisciplinary intellectual stimulation, coordinate access to new funding opportunities, make broader impacts with outreach programs, and organize promotional opportunities.

2. What are the rationale and justification (mission, goals, objectives, relation to campus goals, needs addressed, population served, resources obtained) ?

While the concept of biomimicry is widespread, many attempts to employ this concept result in direct mimicry of biological structures without consideration of the broader context in which evolution operates. Organisms are never perfect, and are always complex, and therefore, direct mimicry is usually misguided. Rather, CEM is based on two distinctive principles: (1) Principles, not mimicry, and (2) Evolutionary variation is the critical ingredient for developing novel bioinspired materials. An overarching goal of CEM is to enable researchers to work together around common principles uncovered in biological investigations. Meeting this goal requires integration across biologists, material scientists, mechanical engineers, chemical engineers, physicists, and medical doctors to uncover key properties arising from biological systems, and then using these principles to create novel materials. Another goal of CEM is to take advantage of the remarkable variation among species in form, structure, and material properties to create new “hybrid” materials that take advantage of advantages in different organisms while circumventing key weaknesses. In this manner, researchers within CEM will not work to directly mimic biological structures, but will examine how the same structure in different species might enable a higher level of performance in a bioinspired material than might normally be observed within a single species.

The Center originally received provisional support from the Dean of the College of Natural Sciences. We now seek official approval from the University to fully establish the Center. The objectives of the Center for Evolutionary Materials are:

Research: To develop interdisciplinary, collaborative research programs that propose, test, and establish the principles of evolutionary materials design.

We propose to build a Center comprised of multiple Focused Research Groups (FRG)

FRG will focus on a particular topic area and would involve at least 2 PIs

Example topic areas may include: bite mechanics/resistance/puncture resistance, biomechanics, locomotion, adhesion, sustainable habitat structures, protective materials, environmental materials, and prosthetics Topics will build upon established expertise in soft materials, interfaces, adhesion, anatomical structures, locomotion, and bite mechanics. FRG will go after focused funding opportunities and write multi-PI papers targeting high tier journals.

Multiple FRG may be united for larger funding opportunities.

Researchers can be in more than one FRG.

Education: To educate undergraduate and graduate students in established principles through research projects and innovative coursework.

This objective is met with lab-based education opportunities for graduate and undergraduate researchers.

Additionally, a monthly seminar program with “materials” and “bio” topics covered. Future plans include to developing at least one course for graduate students and establishing a Research Experience for Undergraduates (REU) program to formalize principles

Outreach: To inspire students at the K-12 level and the general public through outreach programs that demonstrate the impact of evolutionary materials design.

Simple ideas: lab tours, classroom discussion of bio-inspired examples

BioInspire! K-12 unit developed to expose students to scientific prototype development inspired by naturally occurring adaptations, while maintaining the creativity of the art room.

Future plans: create Art/Science high school elective course integrating the creative space of the art room with the design experience of an engineering class.

Technology Transfer: To transfer knowledge, innovations, and philosophical strategy to current and future scientists and engineers in industry and government laboratories.

Establish a CUMIRP Part I Cluster

Invite companies and private donors to witness and participate in the CEM projects

Advertise the principles behind CEM-based research

FRG topics provide concrete ways to connect to industrial sponsors

3. What are the specific activities planned as an on-going part of the enterprise (types, quantities of activities, meetings, publications, seminars, research)?

Research Accomplishments and Plans:

While operating under interim status Center has established, and plans to continue in the future, interdisciplinary, collaborative research programs that encourage intellectual stimulation between departments that traditionally collaborated to a

minimal extent. This collaboration is based on monthly meetings with faculty, graduate students and postdocs from Polymer Science and Engineering, Biology, Chemical Engineering, Civil Engineering, Electrical and Computer Engineering, Mechanical and Industrial Engineering, Physics, and Dermatology. Several of these collaborations have evolved into research with support including a 2016 UMass President's Office S&T Fund Award (\$125,000), a UMass President's Office Creative Economy Fund Award (\$18,686), and an Office of Naval Research Broad Research Call award of \$2,646,990 funding the collaborative research of 4 CEM members (Crosby, Lee, Peyton and Tew).

Recently, Crosby, along with fellow CEM researchers Hayward and Schiffman, led the development of an NSF Science and Technology Center (STC) pre-proposal. This proposal for a Living Interface STC proposed to unite 31 faculty members, 35 graduate students, and 3 postdoctoral members on fundamental science and the technology development for interfaces between biological and synthetic materials. This pre-proposal received strong reviews and serves as a foundation for future CEM-wide research initiatives.

Currently an ADVANCE Mutual Mentoring proposal is being developed by CEM Faculty Katsumata, Bradley, Crosby and Irschick to build and solidify relationships between senior faculty, junior faculty, graduate students and program officers of funding sources to promote the acquisition of funding in current areas of interdisciplinary research interests.

Education Accomplishments and Plans:

Invited Guest Seminars will continue to be held minimally on a biannual basis to continue stimulating interdisciplinary intellectual collaborative dialogue. Selected past seminars include:

December 5, 2019, Thomas Scheibel, University of Bayreuth, Department of Biomaterials: Bioengineering and Processing of Spider Silk Proteins for Various Applications

May 14, 2018, Thomas Roberts, Brown University, Department of Ecology and Evolutionary Biology: Exploring the Role of Muscle Elasticity: Do the Springs in Your Muscles Put a Bounce in Your Step?

March 12, 2018, Neel Joshi, Harvard University, School of Engineering and Applied Sciences, Wyss Institute for Biologically Inspired Engineering: Biologically Fabricated Materials Composed of Engineered Biofilm Matrix Proteins

On June 24, 2019 the Center successfully launched its first annual symposium - New Frontiers in Bioinspiration with more than 50 attendees from multiple universities such as Williams College, Harvard, and MIT at the following presentations:

- George Lauder, Professor of Biology, Harvard University: Tuna robotics: a high-frequency experimental platform exploring the performance space of

swimming fishes

- Diane Kelly, Senior Research Fellow, University of Massachusetts Amherst: Hydrostat diversity and collagen organization: Changing stiffness and shape with fiber winding, packing, and pulling
- Jessica Schiffman, Associate Professor of Chemical Engineering, University of Massachusetts Amherst: Bioinspired materials meet microbiology
- Caitlyn Butler, Associate Professor of Civil and Environmental Engineering, University of Massachusetts Amherst: Engineering biofilms for treatment of environmental systems
- Niels Holten-Andersen, Associate Professor of Materials Science and Engineering, - Massachusetts Institute of Technology: Do bio-inspired metal-coordination crosslinking offer anything unique (and useful) for engineers of hydrogels?
- Jun Yao, Assistant Professor of Electrical and Computer Engineering, University of Massachusetts Amherst: Biological Protein Nanowires for Energy Harvesting and Neuromorphic Electronics

Plans are well underway for the 2nd symposium which will be held on June 15, 2020.

Future plans include to developing at least one course for graduate students and establishing a Research Experience for Undergraduates (REU) program to formalize principles

Technology Transfer Accomplishments and Plans:

The Center established a Part I CUMIRP Cluster in October 2015. Currently, the Cluster has 2 industry sponsors (Gore and CiDRA) supporting CEM Cluster A research with \$20,000 for FY2019 and \$30,000 for FY2020 and has several other companies interested.

Outreach Accomplishments and Plans:

The Center makes impacting the broader community a priority by initiating Outreach Programs with local schools with multiple programs. Collaborations with Ron St.Amand, Director of Science in Springfield Public Schools and 6th grade teachers at Wildwood Elementary in Amherst to educate students about evolutionary materials by bringing 100+ students to campus for a presentation about bioinspired materials and tours of Crosby (PSE) and Irschick's (Bio) laboratories. The Center sponsored 4 outreach activity tables at the Amherst Science Night with more than 200 student participants on April 10, 2019. A CEM collaboration with Nicole Singer, Art teacher at Fort River Elementary and Juliana Tordella (UMass Commonwealth Honors graduate) integrated evolutionary materials education into the Art classroom with the creation of BioInspire! a unit of curriculum developed for eventual wide-spread dissemination to other educators to expose students to the process of looking to natural adaptations to creatively design an engineering problem solving prototype.

4. How does this enterprise differ from other offices or activities on campus with similar names, missions, interests?

Presently there are no other bioinspired materials centers on the UMass campus. More specifically, there are no other centers that focus on interdisciplinary collaboration with the focus of evolutionary materials design.

Institutional Relationships and Governance

1. List all University units involved and describe administrative arrangements with them, if any.

The Co-directors are faculty in the departments of Biology and Polymer Science and Engineering while the 23 faculty Center members represent Polymer Science and Engineering, Biology, Chemical Engineering, Civil Engineering, Electrical and Computer Engineering, Mechanical and Industrial Engineering, Physics, Dermatology, and Radiology. This center will exist within the College of Natural Sciences but will be open to faculty and their students from all colleges on campus.

2. Describe any organizational relationships (as distinct from funding sources) with other agencies, public or private, outside the University.

At this time, CEM does not have any official relationships but the goal is to interface/engage with both industry and education groups.

3. Describe the organization's advisory board or other governance group.

Department Head of Polymer Science & Engineering
Department Chair of Biology
CUMIRP Director

4. Will this be an institute — an independent organizational unit, acting as a department for purposes of non-faculty personnel actions and appointments, able to solicit its own funds without departmental head approval?

No

Comments: This will not be an institute

5. If a center, describe the relationship within the department or college to which this organization is subordinate.

This Center will operate within the College of Natural Sciences

6. Describe arrangements for any patent rights, copyrights, or other ownership components of activities, and any restrictions on access to research information.

Patent ownership would follow established rules determined by the funding sources and UMass policy. In general all individuals in the center will follow policy as to ownership along with industry partners and external funding sources

Resources

1. Describe the space available for use by the organization. (If this is not a permanent location, indicate other space arrangements that are to be made in the future, if known.)

Currently the Co-directors use their faculty offices and the Program Manager occupies office space located in Conte research center. The outreach and education classroom and conference space will be reserved as needed. Research will be conducted in lab space used by Center PIs.

2. Describe any requests for space that have been made.

Office space in Conte for the Program Manager was requested and granted.

3. Describe any repairs, renovations, major equipment needed to make the space you have useful to the organization.

Not relevant at this point

*4. If University employees or students are or will be using space, describe the arrangement. Center outreach activities and events, such as seminars, will invite non-employees to attend, but will always occur in coordination with Center employees.
Staffing (when operation is fully developed)*

1. Non-Faculty (provide rank or grade, student status, working title, FTE, source of funding). Jennifer Green, Grade 15, Administrative Assistant I, 85% FTE, Grant Funded

2. Faculty involved (provide name, department, extent involved, release time arrangement, if any):

Alfred Crosby, PSE, Codirector

Duncan Irschick, Biology, Codirector

Craig Albertson, Biology, Member

Trisha Andrew, Chemistry, Member

Laura Bradley, PSE, Member

Patricia Brennan, Biology, Member (Mt. Holyoke College)

Caitlyn Butler, Civil Engineering, Member

Anthony Dinsmore, Physics, Member

Seth Donahue, BiomedE, Member

Gregory Grason, PSE, Member

John Harris, Dermatology, Member (UMassMed)

Ryan Hayward, PSE, Member

Reika Katsumata, PSE, Member

Diane Kelly, Biology, Member
Jae-Hwang Lee, MIE, Member
Jungwoo Lee, ChemE, Member
Sarah Perry, ChemE, Member
Shelly Peyton, ChemE, Member
Jennifer Ross, Physics, Member
Christian Santangelo, Physics, Member
Jessica Schiffman, ChemE, Member
Yubing Sun, MIE, Member
Gregory Tew, PSE, Member
Yanfei Xu, MIE, Member
Jun Yao, ECE, Member

3. Describe how the Center or Institute may impact existing teaching responsibilities of participating faculty members through “buy-out” arrangements, reduced teaching loads, or other provisions, and how such impacts will be resolved.

At this point there is no effect

4. Attach a detailed budget showing sources of funding, full-year basic operation costs and anticipated expenditures. (This should show programmatic expenditure descriptions, kinds of funding accounts and amounts by subsidiary accounts as well as alternative funding arrangements or programmatic adjustments to be made if funding sources fail.)

1. Budget for New Enter Approval – Form T CEM 2019

MOTION: That the Faculty Senate approve Creation of a Center for Evolutionary
08-22 Materials in the College of Natural Sciences, as presented in Sen. Doc. No.
22-019.

Budget Summary

Budget Information		
A. Revenues by Source	Fiscal Year 2019	Projected for Fiscal Year 2020
Campus Funds by Department & Type (if known). Example:		
Special State Appropriation		
Grants: DoD ONR- Crosby	\$644,621*	\$651,633
Grants: DoD MURI - Hayward	\$20,340**	\$21,052
Other: IALS (STC Proposal Support)	\$5,000	
Other: CUMIRP Cluster A	\$20,000	\$30,000
Other: UMassGIVES	\$121	
Other: Symposium Registrations	\$1,853	\$2,625
Other: Digital Life***	\$30,244	\$16,180
Total	\$722,179	\$726,490
B. Expenses		
Faculty Salaries/Benefits (<i>include release time</i>)	\$34,565	\$35,774
Staff Salaries/Benefits	\$57,380	\$54,213
Graduate Stipends/Benefits	\$200,968	\$187,291
Research Seed Support		\$4050
Post-Doctoral Salaries/Benefits		
Events (<i>e.g., meetings, symposia</i>)	\$1,800	\$2,625
Travel	\$14,233	\$12,792
Other (<i>specify</i>): Subawards	\$238,012	\$234,601
Other (<i>specify</i>): CG Artists	\$22,012	\$14,803
Other (<i>specify</i>): Materials and Supplies	\$12,380	\$12,661
Indirect Costs	\$140,646	\$158,956
Total	\$721,996	\$717,766

*Second payment of 4 annual installments with a cumulative total of \$2,646,990 (Lead PI - Crosby)

**Funds used to support CEM program manager (Lead PI - Hayward)

*** Digital Life is a Cost Center