STRATEGIC AND IMPLEMENTATION PLAN: EXECUTIVE SUMMARY

The NSF BioPACIFIC MIP (DMR-2445868) operates a national user facility dedicated to creating a nexus for synthetic biology and materials to revolutionize high-performance polymers. Users are uniquely able to elucidate biomaterial structure and function to achieve materials-by-design, construct new bio-derived functional monomers from living organisms, access novel sequence-specific materials (e.g. peptoids), synthesize stimuli-responsive "smart" biomaterials, scale-up biomaterial production, and incorporate state-of-the-art theoretic simulation and machine learning algorithms. BioPACIFIC MIP provides access to scientific expertise, data science tools, and automated experimentation. BioPACIFIC MIP enables access to advanced polymers with superior properties and performance beyond those achievable by traditional methods, driven by five strategic objectives: (1) enabling access to cutting-edge infrastructure, (2) developing high-throughput workflows for bio-derived monomer and polymer production, (3) linking biomaterial structure to function, (4) integrating data-driven experimentation, and (5) building a modern skilled workforce to power the burgeoning bioeconomy.

The BioPACIFIC MIP's interdisciplinary partnership is supported through the California NanoSystems Institutes (CNSI) located at the University of California's Los Angeles and Santa Barbara campuses. The CNSIs serve as a hub that leverages public and private investment to drive interdisciplinary research, translate discoveries into knowledge-driven commercial enterprises, and educate scientists and engineers.

BioPACIFIC MIP Research: BioPACIFIC MIP's in-house research program generates new tools, capabilities, and expertise that can be incorporated into the platform offered to the user community. This highly innovative, MGI-driven research program seeks to not only generate new tools, but to accelerate bio-based material discovery and development by integrating high throughput experimental workflows, cutting-edge characterization tools, and data science. The protocols, procedures, data sets, and material libraries are then leveraged by users to make their own contributions to the field. The program is structured around two highly integrated research projects, called Synergistic Exploratory Thrusts (SETs), each focused on maximizing the impact of BioPACIFIC MIP's open-access Materials Innovation Infrastructure for the user community and addressing grand challenges in sustainable materials (SET 1) and next-generation microelectronics (SET 2).

Experimental User Facilities: BioPACIFIC MIP user facilities have locations at both UCSB and UCLA. The UCLA hub of the BioPACIFIC MIP enables users to accelerate the discovery and scale-up production of bio-derived building blocks and biopolymers using a robotic and automated Living Bioreactor system for gene assembly, amplification, transformation, strain growth, and metabolite analysis. A mineable data library of biosynthetic pathways is under development and will be made available to users. Users also have access to the BioPACIFIC MIP's first of its kind Cryo-EM microcrystal electron diffraction (MicroED) system that provides accelerated 2D and 3D structure determination of small molecules, peptides/peptoids, and semi-crystalline polymers.

The UCSB hub of the BioPACIFIC MIP enables users to complete the Design-Build-Test-Learn cycle for novel bio-derived polymers by providing access to automated synthetic and flow chemistry equipment suites, additive manufacturing tools that accommodate both user-designed and commercial resins, rapid structure-property determination via next-generation X-Ray scattering characterization and high-throughput micro-rheology, advanced simulation tools and holistic data collection, mining, and analysis to inform experimentation and facilitate next-generation materials discovery and design.

Computation, Data, and Artificial Intelligence: The BioPACIFIC MIP computation resources support advanced simulation tools and a Digital Ecosystem of scientific software applications for use in the MIP, including an electronic laboratory notebook (ELN) for recording experimental protocols and observations, a laboratory information management system (LIMS) for aggregating data from synthesis and characterization tools, and a materials library for browsing available BioPACIFIC MIP-synthesized compounds and their associated data sets. The Digital Ecosystem is equipped with an AI assistant and an Application Programming Interface (API) to facilitate data and ML-driven experimental design. BioPACIFIC MIP also offers a Wikipedia-like application (BPM Wiki) that contains information about the instrumentation available to MIP users and provides descriptions and tutorials for Digital Ecosystem. Published data and materials produced from standardized and scalable protocols achieve public visibility via the BioPACIFIC MIP library and LIMS.

Knowledge Sharing: A central pillar of the BioPACIFIC MIP is fostering new modalities of research and education, through sharing tools, codes, samples, data, and know-how. Dissemination of experimental procedures and workflows as well as algorithms for analysis and modeling, is vital to enhance *reproducibility* and *accessibility* for both in-house and external users. This provides a necessary and critical resource for the broader community as research shifts toward autonomous experimentation enabled by developments in AI, robotics, and laboratory automation.

The BioPACIFIC MIP is managed and staffed with technical experts that impart knowledge by training researchers on the proper use of equipment and advise on how to properly set up, carry out, and analyze experiments, and moreover, expand and retain the BioPACIFIC MIP's institutional knowledge base through hands-on interaction with users. Sharing is not envisioned to be a one-way flow of information out of the BioPACIFIC MIP but rather a collaborative partnership between the BioPACIFIC MIP and its users.

Education and Workforce Training: The BioPACIFIC MIP is dedicated to providing a clear connection between researcher training and their career aspirations to empower trainees from diverse backgrounds to become the next generation workforce. The BioPACIFIC MIP provides undergraduate and graduate students, postdoctoral fellows, and participating users training in how to set up and analyze experiments that leverage automation and large data sets, summer school workshops, industry networking opportunities, and transferable professional skill training. Broadening participation of all stakeholders has the highest priority, with a focus on increasing participation of researchers from institutes that do not have significant research infrastructure, such as non-R1 universities. External evaluation of the programs helps monitor progress and ensures success.

This strategic plan outlines how BioPACIFIC MIP will allocate its resources and processes for the NSF Materials Innovation Platform (MIP) National user facility.

1. FACILITY OVERVIEW

VISION

BioPACIFIC MIP aims to provide the broad scientific community access to a pioneering **Materials Innovation Infrastructure** for the development of advanced bioderived materials by merging high-throughput synthetic biology and synthetic chemistry, advanced characterization, data integration, and multi-scale computational methods. Through the operation of a unique national user facility, BioPACIFIC MIP integrates cutting-edge research infrastructure and technical staff expertise with sharing of knowledge and data to unlock an entirely new paradigm for sustainable materials research.

Solutions for a sustainable future depend upon new approaches to materials research and development. MGI-driven approaches can accelerate the intentional development and design, manufacturing, and use of materials that promote sustainability, circularity, and environmental compatibility. BioPACIFIC MIP asserts that a **convergence of synthetic biology and synthetic chemistry** offers the key to unlocking the potential of sustainable materials. Strategies that bridge these fields have multiple enabling advantages for constructing advanced materials that protect the environment: (i) microorganisms engineered to create a vast array of novel monomers and/or polymers sustainably; (ii) bio-derived monomers possessing a high degree of functionality (e.g., exchangeable bonds and heteroatoms) that promote circularity and degradability; (iii) biomolecules providing access to polymers of precise sequence and size; and (iv) bio-derived building blocks providing an alternative to petroleum-based materials. Collectively, these features will enable the discovery and creation of advanced materials with novel properties and provide a pathway to transition from petroleum-based feedstocks and single-use plastics.

Harnessing synthetic biology for materials discovery requires the integration of diverse and disparate communities that utilize a wide range of equipment, workflows, and methods of knowledge sharing. However, development of new advanced materials through traditional methods can take decades to discover and decades more to fully deploy. As highlighted in the 2024 NSF Autonomous Materials Innovation Infrastructure (AMII) report, the development of **autonomous experimentation methodologies** is key to unlocking the door to vast troves of materials data, rapidly designing new materials with fit-to-purpose properties, and thereby realizing solutions for a sustainable future. The establishment of these foundational capabilities will significantly accelerate, and fundamentally transform, how the materials community conducts research in the future.

As a Materials Innovation Platform, BioPACIFIC MIP is charged with:

1. Developing next-generation experimental and computational tools, as well as advancing the capabilities of current state-of-the-art tools.
2. Conducting in-house research by a transdisciplinary team in a focused topic designed to address a grand challenge of fundamental science and meet a national need.
3. Operating a user facility that provides unique research tools, samples, data, and technical services to a diverse community of external researchers at various institutions.
4. Serving as an educational focal point for training the next generation of tool developers and users.
5. Building and nurturing a scientific ecosystem, which includes in-house research scientists, external users and other contributors who share tools, codes, samples, data, and know-how to strengthen collaboration among the scientists and enable them to work together in a new modality.

MISSION

BioPACIFIC MIP increases the pace of development of functional materials by focusing on five strategic objectives (**Figure 1**):

1. Democratize access to advanced research infrastructure and expertise built on the unification of high-throughput instrumentation, state-of-the-art characterization tools, and standardized data management infrastructure necessary to drive the discovery and scalable production of sustainable bio-derived materials.
2. Create modern methods to produce non-petroleum-based monomers using high-throughput synthetic biology and synthetic chemistry workflows.

3. Establish the link between structure and function to enable advances in the production of bio-based materials.
4. Integrate computational and data science tools with automated methods for collection, curation, and analysis of multimodal data to improve knowledge sharing and accelerate bio-based material design.
5. Modernize and expand opportunities for U.S. researchers to actively participate in cutting-edge research, thereby building a diverse, skilled, and engaged workforce of scientists and engineers trained in the nexus of automated synthetic biology, chemical synthesis, data driven experimentation, and theory.

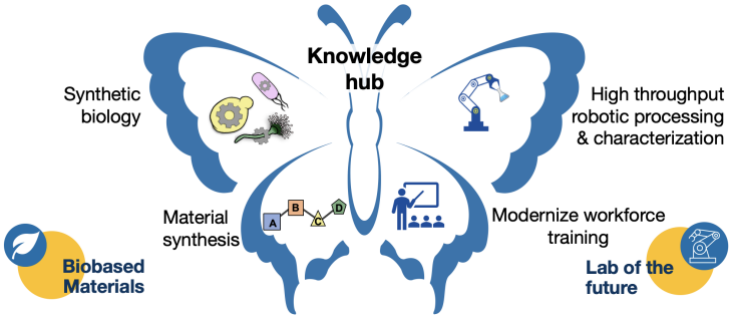


Figure 1: BioPolymers, Automated Cellular Infrastructure, Flow, and Integrated Chemistry (BioPACIFIC MIP).

BioPACIFIC MIP interdisciplinary team and expertise: The BioPACIFIC MIP faculty represent a wide range of disciplines including material science, chemical biology, chemistry, mechanical and chemical engineering, computer science, and statistics and applied probability. This collection of expertise is coupled with a highly skilled team of project scientists and engineers who contribute to discovery, innovation, and dissemination in support of the MIP mission. Collectively, BioPACIFIC MIP provides users from an extensive array of academic and industry partners with the tools and technology guidance needed to make new breakthroughs in biomaterials, even if they themselves do not have the necessary expertise.

Knowledge sharing with all tiers of stakeholders: Collaboration is crucial to building a Knowledge Sharing ecosystem. BioPACIFIC MIP ensures widespread access to generated data, protocols, materials, and technical know-how to foster knowledge sharing and catalyze innovation. Dissemination of experimental procedures and workflows as well as algorithms for analysis and modeling, is vital to enhance *reproducibility* and *accessibility* for both in-house and external users. This provides a necessary and critical resource for the broader community as research shifts toward autonomous experimentation enabled by developments in AI, robotics, and laboratory automation.

Education/training goals: A key mission of the BioPACIFIC MIP is to establish a hub that educates the next generation of scientists and engineers with the kind of interdisciplinary expertise that is not currently available in a single group or institution. A key part of this goal is to provide training in Labs of the Future: how to set up and analyze experiments that leverage automation and large data sets. This training is coupled with programs that develop students' "soft" skills such as communication and project management. To maximize impact and provide networking opportunities, a summer school taught by BioPACIFIC MIP personnel along with leaders in the field from industry, academia, and national labs is held each year. The summer school is open to undergraduate and graduate students and postdoctoral researchers, and offers hands-on training with BioPACIFIC MIP instrumentation, professional development, and training in crafting scientific proposals. The school not only serves as an education vehicle, but it also serves as a recruitment tool to bring a diverse cohort of users into the BioPACIFIC MIP. The BioPACIFIC MIP seeks to provide a

clear connection between researcher training and their career aspirations and to empower the trainees from diverse backgrounds to become the next generation workforce.

Legacy of BioPACIFIC MIP: Through integration of cutting-edge technology and a collaborative ethos, sustained outcomes of BioPACIFIC MIP will (1) advance a national user facility that unlocks automated synthetic biology as a platform for materials science research in the United States; (2) catalyze a community-wide shift to flexible, autonomous experimentation; (3) democratize access to experimental and data infrastructure to support development of bio-based polymers; and (4) produce a new generation of industrial and academic researchers versed in the MGI methodology and poised to lead the next wave of scientific breakthroughs.

GOALS

BioPACIFIC MIP serves as a unique knowledge hub for biomaterials innovation, by interconnecting four key components: (1) an open-access user program, (2) knowledge sharing, (3) in-house research, and (4) education and workforce development. Looking ahead, the most important measurable accomplishments will emphasize novel products from BioPACIFIC MIP in-house research and users.

1. Material Products from In-house Research

The discovery and creation of advanced biomaterials with novel properties is the central focus of the BioPACIFIC MIP. We have successfully developed and demonstrated protocols and procedures for potential users; but the promise of using inverse design to discover a material that marries synthetic biology with chemistry and is created using high-throughput workflows around the MGI loop remains unfulfilled. The next phase of the in-house research program tightens focus on demonstrating materials with novel properties and originating from building blocks developed on the living biofoundry, while leveraging mission-oriented challenges in sustainable materials, next-generation microelectronics, and advanced additive manufacturing as application-relevant testbeds.

Key Metric: The number of novel biomaterial products that are inaccessible from conventional petroleum-derived building blocks, enabled by the integration of the living biofoundry, high-throughput synthesis and characterization platforms, and advanced data analytics, added to the BioPACIFIC MIP library and made available to the community.

Rationale: This represents a true demonstration of BioPACIFIC MIP capabilities and MGI goals

Milestones, Deliverables, and Timeline:

Mid-term Priorities (Years 2027 to 2028)

- Develop at least 2 materials per in-house research Synergistic Exploratory Thrust (SET).

Long-Term Priorities (Years 2029 to 2030)

- Develop at least 2 materials per SET that start from inverse design principles.

Challenges:

- Volume of materials produced from the living biofoundry required to support material development
- Data volumes required to enable AI-driven inverse design
- Use data- and physical-driven models (at every step) to optimize synthesis and fabrication to predict the material properties and performance

Methods for achieving:

- Further tighten MGI integration to accelerate discovery and scale up

- Develop closed loop approaches to enable synthesis exploration and material performance optimization
- Ensure >95% compliance with usage of the BioPACIFIC MIP Digital Ecosystem

2. Ratio of User Products to In-house Research Products

Solutions for a sustainable future depend on new approaches to materials research and development, especially those that enable rapid, fit-for-purpose design through access to high-quality data and tools. BioPACIFIC MIP has laid the groundwork through a robust user program, but to fully realize the vision of a community-driven innovation ecosystem where demand for the platform's resources (tools/people) exceeds the existing bandwidth, broader engagement is essential. In the next phase, we will continue to develop new methods to expand the user program and increase the proportion of user-generated products — including materials, workflows, data, publications, and presentations. This metric is a key indicator of the national impact of BioPACIFIC MIP, the broadening of the diversity of biomaterials being developed across the United States, and the potential for operational sustainability of the MIP.

Key Metric: The ratio of user products to products developed by the in-house research (IHR) effort

Rationale: Achieving this metric would serve as a demonstration of BioPACIFIC MIP's impact and criticality to the national user community.

Milestones, Deliverables, and Timeline:

Mid-term Priorities (Years 2027 to 2028)

- Achieve a 1:1 ratio of user products to IHR products

Long-Term Priorities (Years 2029 to 2030)

- Demonstrate a >2:1 ratio of user products to IHR products

Challenges:

- Enabling a culture shift to high-throughput experimentation
- Long intervals between MIP experimentation and publication
- Effective knowledge sharing modalities

Methods for achieving:

- Launch targeted funding calls in synthetic biology and chemistry, leveraging the MAPS tool to identify high-impact, facility-accessible targets within BioPACIFIC MIP; including a competitive component that challenges user to apply MAPS to design and demonstrate novel biomaterials
- Create a consolidated open access database of successful workflows
- Reorganize the annual user meeting to improve user-user interaction

SUSTAINABILITY

BioPACIFIC MIP will draw on the extensive experience at UCLA and UCSB in developing and operating research centers and user facilities to ensure the BioPACIFIC MIP has a smooth transition to sustainable operations following the culmination of NSF/DMR funding. This transition will require a multipronged approach that includes: (1) transitioning users from the internal and external academic communities and from industry to a pay-for-use model to offset some of the costs of running a user facility; (2) continuing investment in the entrepreneurial training of students and postdocs who will start, or have, companies and will be future users/investors; (3) building on relationships with industry collaborators to grow BioPACIFIC MIP's innovation ecosystem to form supporting partnerships; (4) applying for federal funding that leverages the existing infrastructure, including from DoD, NIH, and NSF, including the NSF Engineering Research Center (ERC) to further capitalize on this innovation ecosystem in bio-based materials, training grants to

sustain workforce development efforts, and programs such as PREM and PREC to further drive diverse engagement; (5) leveraging multi-year foundation and philanthropic development efforts at both campuses to support specific research projects and student training directed towards environmental impact and the development of sustainable/degradable plastics.

2. MANAGEMENT

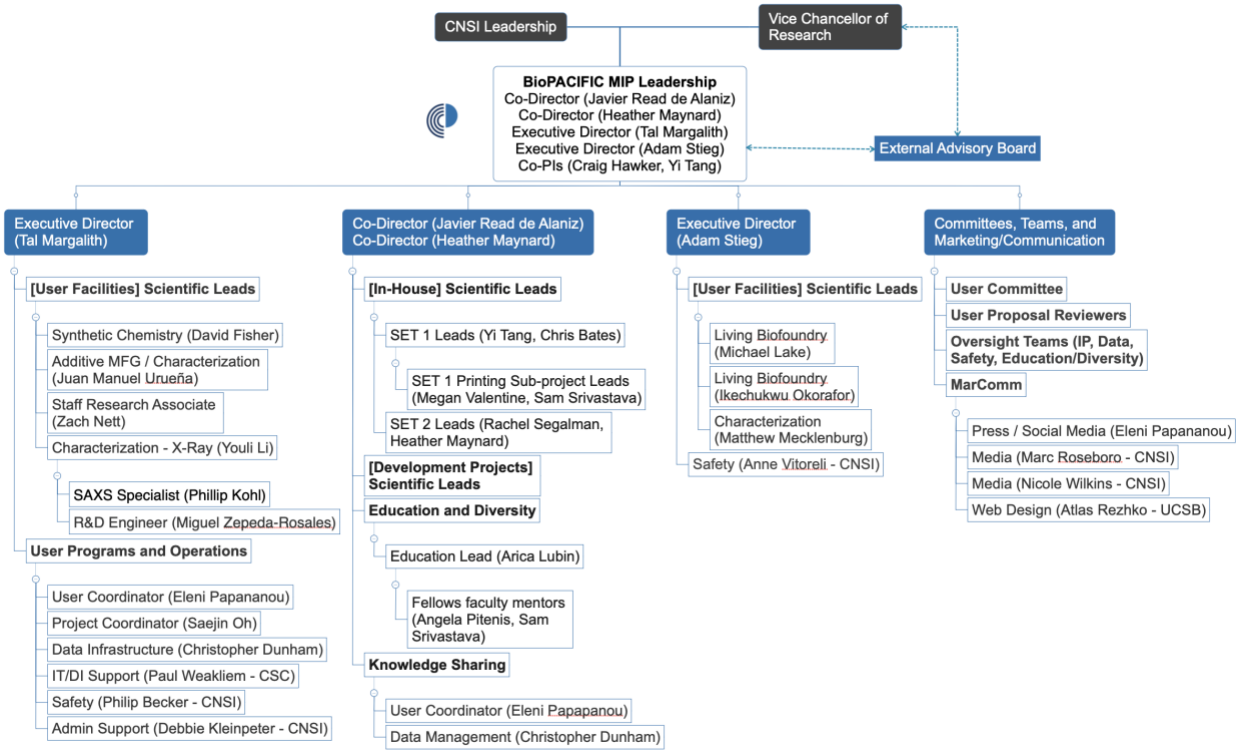


Figure 2: BioPACIFIC MIP Organizational Chart.

OVERVIEW

The BioPACIFIC MIP's Leadership team includes Javier Read de Alaniz (PI, Co-Director, UCSB), Heather Maynard (Co-PI, Co-Director, UCLA), Tal Margalith (Executive Director, UCSB), and Adam Stieg (Executive Director, UCLA). Co-PI's Craig Hawker (UCSB) and Yi Tang (UCLA) join the leadership team in discussions with the EAB and campus leadership at UCSB and UCLA. In the next funding cycle, Rachel Segalman (UCSB) will join the leadership team as Co-PI. UCSB staff and the BioPACIFIC MIP User Coordinator, hired to facilitate user access and to recruit new users, report to Read de Alaniz and Margalith, while UCLA staff report to Maynard and Stieg. The Leadership Team oversees all aspects of the MIP including research, operations, education, and knowledge sharing. Read de Alaniz and Maynard coordinate the in-house scientific activities of the BioPACIFIC MIP Fellows, platform development project leads, and the scientific leads of the Synergistic Experimental Thrusts (SETs).

The SET and development project leads work with the other senior participants to direct the in-house research of BioPACIFIC MIP's postdoc and graduate students. Margalith and Stieg coordinate facilities

setup and operation, marketing/communication efforts, and the user program, including establishing and collecting user fees, as appropriate. Lubin oversees education and mentoring programs for graduate student and postdoctoral researchers and coordinates with the User Coordinator Papananou. At both campuses, the BioPACIFIC MIP will be administered by the California NanoSystems Institute (CNSI). This allows for significant leverage, with CNSI supporting BioPACIFIC MIP through space allocation for equipment and research, access to existing shared experimental facilities, and multiple administrative support personnel. CNSI leads that are also involved in NSF BioPACIFIC MIP includes Profs. Hawker and Valentine (CNSI Co-Directors at UCSB), Maynard (CNSI Associate Director at UCLA), and Tal Margalith and Adam Stieg (CNSI Executive Directors at UCSB and UCLA, respectively). The BioPACIFIC MIP leadership and operations teams will continue to meet weekly (at minimum). Additionally, the UCLA and UCSB operations teams will continue to hold joint biweekly meetings via video teleconferencing.

EXTERNAL ADVISORY BOARD

The BioPACIFIC MIP External Advisory Board (EAB) is primarily responsible for ensuring that BioPACIFIC MIP remains relevant on the national scale and guiding long-term strategic growth. The EAB will meet quarterly *via* video teleconference.

Professor Geoff Coates – Leadership: Prof. Coates is the Tisch University Professor at Cornell University. He is a leader in both polymer science and entrepreneurial activities. He is a member of the National Academy of Sciences and is the recipient of the Presidential Green Chemistry Challenge Award and Kathryn C. Hach Award for Entrepreneurial Success. He is an associate editor of *Macromolecules* and a member of editorial advisory boards of a number of journals. **Expertise**: His research group focuses on the development of new synthetic strategies that rely on commodity feedstocks for producing polymers with well-defined composition, architecture, stereochemistry and molar mass.

Professor LaShanda Korley – Leadership: Prof. Korley is the Co-Director of Center for Hybrid, Active, and Responsive Materials (CHARM), the University of Delaware MRSEC supported by the National Science Foundation, and the Associate Director of the University of Delaware Center for Research in Soft Matter and Polymers (CRiSP), and a Distinguished Professor of Materials Science and Engineering. She is an American Institute for Medical and Biological Engineering Fellow. **Expertise:** Her research utilizes a bio-inspired approach to develop polymeric materials with mechanical tunability and responsive features for applications that range from biomedical engineering to protective fabrics.

Dr. Kermit Kwan – Leadership: Dr. Kwan served as Manager of R&D Technology from 2006-2012 and Technology Manager of the Foams R&D department from 2012-2016 for Solvay. He is currently the R&D Program Manager for Solvay's stimuli-responsive polymers program. **Expertise:** Solvay is an international chemical and advanced materials company with diversified markets, including aerospace, electronics, and energy materials. Dr. Kwan's emphasis is on polymer physics and stimuli-responsive materials.

Professor Gabriel P. López – Leadership: Dr. López is a professor of Chemical and Biological Engineering at the University of New Mexico. He served as the director of the NSF's Research Triangle Materials Research Science and Engineering Center, which focused on the programmable self-assembly of soft matter. He also served as the Vice President of Research at the University of New Mexico. **Expertise**: His research is at the interface of biointerfacial phenomena, biomaterials, self-assembly and bioanalytical microsystems.

Dr. Josh Speros – Leadership: Joshua Speros joined BASF Venture Capital as an Investment Manager in February 2022. From 2017-2022 he served as an Innovation Manager at the BASF California Research Alliance, where he launched collaborative research projects with academic partners, supported startup relationships, and participated in California's innovation ecosystem. **Expertise:** Through BASF and CARA, Dr. Speros brought together researchers from widely varied science and engineering disciplines that strive to make next-generation materials, formulations, and digital tools. In his current role he has visibility into next generation technologies.

Professor Karen Wooley – Leadership: Prof. Wooley is the W.T. Doherty-Welch Distinguished Professor at Texas A&M University (TAMU). She is the director of TAMU Laboratory for Synthetic-Biologic Interactions, member of the National Academy of Sciences, Executive Editor of *Journal of American Chemical Society*, and serves on a number of advisory boards within the broader scientific community. **Expertise**: She is a leader in the field of polymer synthesis with an emphasis that spans the development of anti-biofouling coatings, tissue-selective targeting and tissue engineering, and the advancement of methodologies for the selective polymerization of multi-functional monomers.

Professor Huimin Zhao – Leadership: Prof. Zhao is the Steven L. Miller Chair Professor of Chemical and Biomolecular Engineering and professor of chemistry, biochemistry, biophysics and bioengineering at the University of Illinois at Urbana-Champaign. He is the theme leader of the biosystems design theme in the Carl R. Woese Institute for Genomic Biology and the leader of the conversion theme in the DOE's Center for Advanced Bioenergy & Bioproducts Innovation (CABBI). **Expertise:** Zhao's group develops and applies synthetic biology, machine learning, and laboratory automation tools to engineer functionally improved or novel proteins, pathways, and genomes for biotechnological and biomedical applications.

Dr. Ron Zuckermann – Leadership: Dr. Zuckermann spent 14 years at the Molecular Foundry where he served as a senior scientist and facility director, as well as the director of their user program. Served as a Chiron Research Fellow and the director of Bioorganic Chemistry at Chiron corporation. **Expertise:** His research is focused on using sequence-defined peptoid polymers to bridge the gap between structural biology and polymer science.

ADDITIONAL BIOPACIFIC MIP MANAGEMENT TEAMS AND COMMITTEES

Data Team – responsible for BioPACIFIC MIP's data infrastructure and management plan. The team drafts and adjusts strategies related to data systems (e.g., ELN and LIMS), computing hardware, data architecture for sharing, mining, and Machine Learning, and hiring the Computation and Data Specialist.

- Christopher Dunhan, Computation and Data Specialist, BioPACIFIC MIP, UCSB
- Mengyang Gu, Professor, Statistics and Applied Probability, UCSB
- Tal Margalith, Executive Director, BioPACIFIC MIP, UCSB
- Scott Shell, Professor, Chemical Engineering, UCSB
- Saejin Oh, Postdoctoral Researcher, UCSB
- Adam Stieg, Executive Director, BioPACIFIC MIP, UCLA
- Paul Weakliem, Director, Center for Scientific Computing, UCSB

Education and Training Oversight Team – responsible for fellow training and summer school. The team drafts and adjusts strategies related to professional development programs, recruitment of Fellows and Associates, summer school goals and programming, and broadening participation in the user program.

- Arica Lubin, Associate Director, Center for Science and Engineering Partnerships, UCSB
- Rita Blaik, Education Director, California NanoSystems Institute, UCLA
- Tal Margalith, Executive Director, BioPACIFIC MIP, UCSB

- Heather Maynard, Co-Director, BioPACIFIC MIP, UCLA
- Eleni Papananou, User Coordinator, BioPACIFIC MIP, UCSB
- Javier Read de Alaniz, Co-Director, BioPACIFIC MIP, UCSB
- Adam Stieg, Executive Director, BioPACIFIC MIP, UCLA

Intellectual Property Oversight Team – ensures generated intellectual property is disclosed and protected. The team tracks IP generated by the MIP and drafts and adjusts strategies to train local/in-house BioPACIFIC MIP faculty, staff, and students on how to create IP and avoid IP conflicts with MIP users.

- Tal Margalith, Executive Director, BioPACIFIC MIP, UCSB
- Heather Maynard, Co-Director, BioPACIFIC MIP, UCLA
- Sherylle Mills Englander, Executive Director of Strategic Initiatives and Operations, CNSI, UCSB
- Amir Naiberg, Director, Technology Development Group, UCLA
- Javier Read de Alaniz, Co-Director, BioPACIFIC MIP, UCSB
- Adam Stieg, Executive Director, BioPACIFIC MIP, UCLA

Safety and Access Oversight Team – responsible for training and facility operation protocols. The team drafts and adjusts strategies related to laboratory operations and user training to insure a safe environment.

- David Fisher, Project Scientist, BioPACIFIC MIP, UCSB
- Philip Becker, Building Manager, Elings Hall / CNSI, UCSB
- Michael Lake, Project Scientist, BioPACIFIC MIP, UCLA
- Tal Margalith, Executive Director, BioPACIFIC MIP, UCSB
- Matthew Mecklenburg, Project Scientist, BioPACIFIC MIP, UCLA
- Eleni Papananou, User Coordinator, BioPACIFIC MIP, UCSB
- Adam Stieg, Executive Director, BioPACIFIC MIP, UCLA
- Juan Manuel Urueña Vargas, Project Scientist, BioPACIFIC MIP, UCSB
- Anne Vitoreli, Environmental Health and Safety, CNSI, UCLA

User Committee – advisory committee to align goals and plans with user needs.

- Comprised of external and local BioPACIFIC MIP users; the 2024 committee was chaired by Prof. Tristan Clemons (University of Southern Mississippi).

Note: Committees and names of affiliates are listed in alphabetical order.

MEETING SCHEDULE:

The BioPACIFIC MIP leadership meets weekly (at minimum) to discuss operations:

- UCLA led operation meeting participants are Heather Maynard, Adam Stieg, Michael Lake, Matthew Mecklenburg, Ike Okorafor, Christopher Dunham, and Eleni Papananou, with Javier Read de Alaniz and Tal Margalith, as needed (Wednesdays).
- UCSB led operation meeting participants are Javier Read de Alaniz, Tal Margalith, David Fisher, Juan Manual Urueña Vargas, Zachary Nett, Christopher Dunham, Youli Li, Eleni Papananou, Saejin Oh, and Debbie Kleinpeter, with Heather Maynard and Adam Stieg, as needed (Tuesdays).
- UCSB and UCLA executive team meeting participants are Javier Read de Alaniz, Tal Margalith, Heather Maynard, Adam Stieg, and Debbie Kleinpeter, with Eleni Papananou and Arica Lubin, as needed (Friday afternoon).

Additionally, the UCLA and UCSB operations teams hold a joint biweekly meeting via video teleconferencing (alternate Mondays).

- Bi-weekly SET meetings; graduate students and postdocs, staff, and faculty at both UCSB and UCLA - virtual
- Quarterly all-hands site meeting alternating between campuses – in-person
- Annual day-long technical conference with invited speakers drawn from the BioPACIFIC MIP user community to highlight work conducted at BioPACIFIC MIP; this may be coupled with a session at the American Chemical Society
- Annual User and User Committee meeting, in conjunction with the above conference
- BioPACIFIC MIP Summer School (nominally 2026 and 2028)
- Quarterly External Advisor Board (EAB) meetings (virtual); ensure that BioPACIFIC MIP remains relevant on the national scale and guide the long-term strategic growth

MENTORING PLAN

BioPACIFIC MIP will provide graduate student and postdoctoral mentorship and professional development, with the goal of maximizing research and career success, whether their long-term career goals lie in academia, national laboratories, industry, entrepreneurship, government, or elsewhere. Each funded postdoc and graduate student researcher will be supervised by at least one faculty supervisor within the MIP. Each MIP Advisor will meet with trainees individually to discuss career goals and assess professional development needs, working together to develop **Individual Development Plans (IDPs)**. IDPs will be revised annually and certified by their research advisor and PIs, Read de Alaniz and Maynard. In addition to regular BioPACIFIC MIP and research team meetings, faculty members and trainees will meet monthly to assess progress, identify new professional development activities.

Trainees will be encouraged to **network, present, and hone their communication skills**, especially via travel to conferences, symposia, outreach events and workshops. MIP travel grants will be provided to support conference or other professional event attendance, and trainees will be encouraged to affiliate with one or more professional societies in their field. BioPACIFIC MIP will include **proposal and scientific writing workshops** during the summer schools, and **science communication training** and events throughout the year that promote **collaborating across disciplines and in diverse teams**. To expand their local networks, trainees will be invited to speak at seminars and outreach events and be involved in planning events and choosing and inviting speakers to bring to campus. They will have opportunity to engage with faculty candidates, visitors from academia, industry, and national labs, along with MIP external users, **exposing trainees to a wider community and varied careers.**

Additionally, trainees at both campuses have access to, and will be encouraged to take advantage of, **career counseling and professional development workshops and activities** through the Center for Science and Engineering Partnerships (CSEP) Professional Development Series for graduate students and postdocs at UCSB, and the California NanoSystems Institute (CNSI) Education arm at UCLA. These include **mentoring/teaching training and opportunities** through multiple initiatives and programs that MIP trainees have historically participated in. The Graduate Division and Career Services (CareerHub at UCLA; Graduate Student Resource Center at UCSB) at both campuses provide extensive resources and career development workshops open to all trainees covering topics such as time-management, wellness, IDPs, finding research funding, grant writing, writing effective resumes, and finding jobs outside of academia. At UCLA, the Postdoctoral Association (PDA) also provides resources for IDP development and mentoring and organizes monthly social and networking events for postdoctoral scholars. UCLA and UCSB are a part of the **NSF I-Corps Hub West** and offer a suite of innovation and entrepreneurship resources as well. Each hosts a calendar of workshops and seminars with presenters from both on and off campus who can provide insight and expertise on professional and career development topics. **Instruction in responsible**

professional practices will be provided on a regular basis in the context of the research work and will include fundamentals of the scientific method, laboratory safety, compliance with RCR CITI trainings, data management, and other standards of professional practice.

Additional Resources: UCSB and UCLA are both members of the National Postdoctoral Association, a national organization that provides resources and advocacy for postdoctoral scholars, and postdocs may sign up as affiliate members. The workplace interests of graduate student and postdoctoral researchers across the University of California system are protected by UAW Local 4811, guaranteeing minimum wages and annual raise rates, comprehensive health and benefit plans, AD&D and short-term disability insurance, and voluntary long-term disability insurance.

Assessment: Success of this plan will be assessed through trainee progress tracked via their IDPs, BioPACIFIC MIP quarterly check-ins, pre- and post-program annual surveys, and tracking of progress toward career goals after completing their graduate or postdoc training.

DATA MANAGEMENT PLAN

The success of BioPACIFIC MIP necessarily relies on generated data and associated metadata being Findable, Accessible, Interoperable and Reusable (FAIR). The types and scope of data streams we expect to generate in specific facilities, as well as methods for its collection, storage and sharing, is summarized below.

Living Biofoundry Facility. Automated infrastructure for the production of bio-derived building blocks and biopolymers from yeast, fungi, and bacteria. **Primary data outputs:** instrument data and metadata associated with biological pathway execution, including microbial growth rates (doubling times), microbial cell densities (measured through optical density), compound titer (g/L), compound yield (with respect to limiting nutrient), DNA concentration (measured by absorbance), colony count, and gene sequences. This data is captured as .csv or .txt files.

Synthetic Chemistry Facility. Automated polymerization and flow chemistry tools for synthesis of biomaterials from the monomers developed in the Living Biofoundry Facility and the creation of synthetic counterparts to those materials. **Primary data outputs:** instrument data and metadata associated with chemical synthesis including reaction protocols and input parameters, such as reagents, temperature setpoints, dosing, time durations, and design of experiments, and inline parameters, such as actual temperatures, concentrations, and processing errors. This data is captured as .csv or .txt files.

Additive Manufacturing Facility. 3D printing of standard and custom synthetic and biological resins leveraging both commercial and development printing platforms and in-house bio-enabled 3D printing processes for fabricating bio-enabled materials with a range of material properties. **Primary data outputs:** instrument data and metadata associated with additive manufacturing including input parameters, such as resins, temperature setpoints, curing wavelengths, and design of experiments, and inline parameters, such as actual temperatures, dispense volumes, and processing errors. This data is captured as .csv or .txt files.

High-Throughput Characterization Facilities. In-line analysis of synthetic biology and chemistry workflows and rapid characterization of materials synthesized in the Living Biofoundry, Synthetic Chemistry, and Additive Manufacturing Facilities. **Primary data outputs:** data files containing single point outputs (e.g. viscosity, homogeneity, absorption, molecular weight), .csv or .txt files (e.g. NMR spectra, X-Ray spectra), or images/videos (e.g. from MicroED, SAXS/WAXS, Differential Dynamic Microscopy).

Scientific Computing Facility. Multi-scale simulation tools to predict the properties of synthesized materials; systematically explore the design landscape of new materials achievable with the building blocks from the Living Biofoundry and Synthetic Chemistry Facilities; and suggest new components and/or functionalities as targets for experimental synthesis, incorporating machine learned inputs from an analysis of workflow data and outcomes. **Primary data outputs:** Simulation outputs describing polymer self-assembly and thermodynamic properties in solution or melt, accounting for polymer architecture, chain models, segment interactions, and electrostatic interactions.

To successfully integrate and store data from these facilities, a multi-pronged data management strategy was implemented so that data can be referenced by a uniquely identifiable experimental data structure and corresponding alphanumerical identifier (using universal unique identifier, or UUID, version 4). Users are able to access data management tools through the BioPACIFIC MIP Portal, which is the entry point for BioPACIFIC MIP's Digital Ecosystem.

BioPACIFIC MIP users utilize the BioPACIFIC MIP electronic lab notebook (ELN) through all phases of their project to capture experimental designs and synthetic protocols, target molecular structures, and relevant literature data. The BioPACIFIC MIP Library system is used to catalog newly developed materials and/or biological pathways (where appropriate). BioPACIFIC MIP's laboratory information management system (LIMS) will consolidate instrument data and metadata, ELN data, and characterization data into a common database. Searching the LIMS database via its application programming interface (API) will provide information about both the structure/property data associated with the material and the workflow/pathway data used to produce the material, regardless of whether the material is a chemical or biological product.

The ELN and LIMS platforms afford the additional ability to tag confidential data such that it is only searchable and retrievable by authorized parties. As set out in recently developed policies, although data may be kept confidential through the exaction of user fees, users are otherwise required to contribute the data to the BioPACIFIC MIP for non-commercial use by the user community after any results have been published and any intellectual property has been disclosed within one year of the project's end date.

Published data is open for further dissemination outside of the BioPACIFIC MIP Digital Ecosystem. Explorations will continue with third-parties such as the Community Resource for Innovation in Polymer Technology (CRIPT) at the Massachusetts Institute of Technology. Other work will explore leveraging and providing digital object identifiers (DOIs) through an agent such as Datacite. Other avenues of integration for BioPACIFIC MIP data may include collaborations with the Acceleration Consortium (AC) at the University of Toronto or the Sustainable Minerals, Metals, and Materials (SM3) initiative at the University of Arizona.

All data generated by and stored at BioPACIFIC MIP will be backed up in duplicate or triplicate for varying periods of time, as specified by the needs of individual groups and users, with all data subject to minimum daily and weekly rolling backups for short-term data and one-year backups for long-term data.

SAFETY AND ACCESS ACTION PLAN

The leadership team of BioPACIFIC MIP will leverage a strong tradition of creating, operating, and maintaining open-access facilities in the CNSI at UCSB and UCLA, where we have a demonstrated history of providing and maintaining advanced technical infrastructure for more than a decade. To manage access to and safe utilization of BioPACIFIC MIP resources, we will provide administrative services including: (1) connecting users with technical staff; (2) dissemination of laboratory safety policies and procedures; (3)

coordination of user training activities; (4) assisting visiting users in finding appropriate accommodations; and (5) supporting the technical staff in tracking the usage of tools and consumables for reporting purposes. Specifically, we will utilize existing best practices developed and implemented in the CNSI shared research facilities at both campuses in concert with their respective Offices of Environmental Health and Safety to facilitate access requests for both internal and external users prior to granting laboratory and equipment access.

Responsibility for laboratory safety, including the development of protocols and standard operating procedures, will be taken by dedicated technical staff for each facility, with oversight by the BioPACIFIC MIP leadership and advising from Environmental Health and Safety on each campus. All users will be required to take Fundamentals of Laboratory Safety (available online) and/or provide proof of equivalent training from their own universities. Furthermore, facility staff will provide users laboratory-specific safety training which includes the location of exits, telephones, safety documents, chemical/biohazard spill kits, eye wash stations, and fire extinguishers per UCSB and UCLA requirements (see example). The Living Biofoundry at UCLA is classified as a biosafety level 2 (BSL2) facility and therefore, will not require additional biosafety training. However, users will be required to review the laboratory specific biosafety manual (available online) prior to use of the facility and offered the opportunity to receive additional biosafety training as needed (available online). The in-lab location of this manual will be pointed out to users during the safety orientation. Standard Operating Procedures (SOPs) for all equipment and processes will be developed by BioPACIFIC MIP technical staff and provided to users to ensure safe and effective use of materials, supplies and equipment. Safety Data Sheets (SDSs) for newly prepared chemicals or materials will be prepared in compliance with the OSHA Hazard Communication Standard (HCS) (29 CFR 1910.1200(g) and provided to users to communicate information on potential hazards. Safety documents and protocols for the MIP can be found in the BioPACIFIC MIP Wiki, which includes safety and training documentation and is shared with all in-house and external users of the facilities.

All BioPACIFIC MIP laboratory spaces are secured by centralized keycard access-controlled security systems. Users will only be provided physical access to the facilities following completion and certification of all required safety trainings and laboratory-specific orientations. User access, utilization and tracking will be managed by a centralized laboratory management system, specifically the FBS system at UCSB and at UCLA. These systems: (1) provide a single point of entry for users; (2) track training (safety and equipment) and qualification; (3) enable tool reservations and scheduling for training and consultation; and (4) provide data necessary to track tool or service access as well as supplies and materials usage. Additionally, training records and liability waivers (required for external users) are compiled in a Box drive shared by the Operations teams at UCSB and UCLA.

INTELLECTUAL PROPERTY

For research or services conducted at the BioPACIFIC MIP:

- Any intellectual property developed in the performance of a research project that is performed by non-UC researchers on behalf of a non-UC entity and that is independent from any UC research activities will not be owned by UC.
- With respect to any intellectual property developed in the performance of a research project that is performed jointly by UC researchers and non-UC researchers, ownership shall be determined in accordance with applicable United States intellectual property laws and applicable University policies. In the event that a separate research agreement exists between the parties for the contemplated research project, the terms of that research agreement will govern.

- Any intellectual property developed in the performance of a research project conducted solely by UC researchers will be owned by the UC Regents, except in the case of Services.
- With respect to services conducted by BioPACIFIC MIP staff under the BioPACIFIC MIP's no-charge recharge agreement ("Services") with a non-UC entity, any intellectual property developed in the performance of that project will not be owned by The Regents but only to the extent that there is no UC employee who is a co-inventor of such intellectual property as determined under U.S. patent law.
- The data generated during proprietary research conducted by non-UC researchers on behalf of a non-UC entity can be kept confidential by paying the full recovery costs, following the NSF MIP guidelines expressed in the MIP Programmatic Terms and Conditions (PTC).

Samples and data sent to and from the BioPACIFIC MIP for aid in research, characterization, or materials development will be managed by UCSB and UCLA's standard Materials Transfer Agreements (MTA).

To address and encourage library submissions, upon acceptance of their BioPACIFIC MIP proposals, users will be required to sign a memorandum of understanding (MOU) agreeing to submit pathway data and/or a small volume of materials developed as part of their BioPACIFIC MIP research to the BioPACIFIC MIP libraries. The submissions may be made after publication or filing of IP through the appropriate channels, but within one year of the project's end date. In a manner similar to other data and material repositories (e.g. AddGene.org), materials and data in the BioPACIFIC MIP libraries will be used only for non-commercial research and educational purposes.

3. USER FACILITIES

The BioPACIFIC MIP is committed to building a world-class user facility with shared locations at UC Santa Barbara and UC Los Angeles. All equipment in the BioPACIFIC MIP is managed and operated by staff scientists dedicated to user training, support, and collaboration. Evaluation of impact on an annual basis by BioPACIFIC MIP leadership and staff scientists will help monitor progress and mitigate risk. The BioPACIFIC MIP User Coordinator will work with the staff scientists to effectively communicate with our users the unique research opportunities made available through our user facilities.

Physical access to monomer libraries or transfer of materials and samples to/from UCSB or UCLA will be facilitated and documented by the User Coordinator with the support of user facility staff, all of whom will be trained in current local, state and federal policies for safe transport of chemicals and biological materials (available online).

LIVING BIOFOUNDRY FACILITY AT UCLA

The BioPACIFIC MIP Living Biofoundry Facility (LBF) works with users to accelerate discovery and scale-up production of bio-derived building blocks and biopolymers through automated synthetic biology and microbial engineering. The facility is developing high-throughput methods for gene assembly, amplification, transformation, strain growth, and metabolite analysis as well as preparing to support mineable data library of biosynthetic pathways for the production of unique bio-derived monomers.

The facility is housed at the CNSI building at UCLA (room 2145) and managed by two dedicated project scientists (Dr. Michael Lake and Dr. Ikechukwu Okorafor). The Thermo Fisher Laboratory Automation System (LAS) provides the core platform for the facility that allows high throughput automation of synthetic biology protocols. The LAS features a state-of-the-art Spinnaker microplate robot that integrates an

automated tower incubator and shaker, plate sealers and peelers, PCR thermocyclers, plate fillers, barcode labeler, one-of-a-kind deep well plate washer, centrifuge, plate reader, and Tecan Fluent 780 liquid handler. Major upgrades to the Fluent 780 have added on-deck equipment including a microplate vacuum purification system, two heating/cooling/shaking modules, a plate reader with fluid injection, plate washer with magnetic bead purification and an Alpaqua magnetic bead purification unit.

Workflows that have been developed include polymerase chain reaction (PCR) DNA amplification, PCR product purification, gene refactoring and assembly, microbial transformation, purification of plasmid DNA, and cold solvent extraction of metabolites from cells for LC/MS sample preparation and high throughput enzyme kinetics assays with coacervates, all in 96-well microplate format. The LBF also offers a Thermo Fisher ultra-high-performance liquid chromatography and triple quad mass spectroscopy system for separation and quantification of molecules from biosynthetic pathways. Some of the equipment in the LBF can be used remotely in user projects.

SYNTHETIC CHEMISTRY FACILITY AT UCSB

The BioPACIFIC MIP Synthetic Chemistry Facility features a suite of unique instrumentation in a one-of-a-kind facility that forms the nexus between discovery, materials-by-design, and biomaterial production. This collection of instrumentation includes: (i) the Symphony X solid-phase synthesizer(Gyros Protein Technologies), (ii) the Nexera preparative HPLC (Shimadzu), (iii) the Nexera analytical HPLC (Shimadzu), (iv) the Swing XL automated chemistry platform (Chemspeed Technologies), (v) the R-series flow chemistry system (Vapourtec) with in-line FTIR (Mettler Toledo) and NMR (Magritek) analytics, (vi) a Selekt flash chromatography system (Biotage), (vii) a V-10 touch evaporator (Biotage), and (vii) a benchtop freeze dryer (Labconco).

The facility is housed in the Oasis building near UCSB (71 S. Los Carneros Blvd.) and managed by a dedicated research associate (Zachary Nett) and a project scientist (Dr. David Fisher).

ADDITIVE MANUFACTURING FACILITY AT UCSB

The BioPACIFIC MIP's Additive Manufacturing Facility includes resources for rapid prototyping, advanced manufacturing, soft lithography, and 3D printing. The facility focuses on designing, building, and maintaining custom 3D printing platforms tailored to specific user-defined applications. Featuring state-of-the-art 3D printing processes, the facility routinely fabricates complex structures from novel bio-derived monomers, exhibiting a diverse range of mechanical, transport, optical, and chemical properties.

The facility is housed in the Oasis building near UCSB (71 S. Los Carneros Blvd.) and managed by a dedicated project scientist (Dr. Juan Manuel Urueña Vargas). the facility is equipped with a Carbon M2 printer and a Mono 3Z2 digital light processing (DLP) printer. Carbon's pioneering CLIP technology carefully balances the interaction of UV light, which triggers photopolymerization, and oxygen to inhibit polymerization. This process allows for continuous object construction from a pool of resin, achieving speeds 25 to 100 times faster than traditional 3D printing. The customized Mono 3Z2 DLP printer functions as a high-resolution visible light 3D printer, enabling the development of next-generation panchromatic photopolymer resins using LEDs in the visible spectrum (405 nm violet, 460 nm blue, 525 nm green, 615 nm red, and 730 nm near-infrared) with full control of the of the grayscale for each slice and the UV-Vis dose through adjustments in layer thickness, light intensity, exposure time, temperature, and environment. The facility also houses a dedicated system for the Solution Mask Liquid Lithography (SMaLL) process, capable of 3D printing unique multi-material objects with spatially-resolved mechanical and chemical

properties; a Cellink BioX bioprinter for printing biological components, aqueous gels, and thermosets; and a Cellink LumenX DLP bioprinter.

Workflows include SMaLL, DLP, stereo lithography (SLA), material jetting (PolyJet), and fused deposition modeling (FDM). Users can leverage commercially available thermoplastics, silicones, colloidal suspensions, standard and stimuli-responsive gels, synthetic and biological resins, and even biological components (including living cells) to construct complex, high aspect ratio three-dimensional objects.

HIGH-THROUGHPUT CHARACTERIZATION: X-RAY SCATTERING

The BioPACIFIC MIP small-angle X-ray scattering (SAXS) Facility is a cutting-edge platform instrument for large length scale (~1nm-1000nm) nanostructure characterization of a broad range of bio-inspired materials. The instrument has been custom designed and constructed at UCSB to provide the most advanced capabilities for laboratory SAXS, using the brightest liquid metal jet laboratory X-ray source and the largest, most sensitive hybrid pixel photon counting 2D detector. In many key aspects, the performance of the BioPACIFIC MIP SAXS is comparable to a second-generation synchrotron SAXS, thus enabling laboratory based rapid-turnaround/high-throughput SAXS and WAXS data collection to meet the demand of the large research community at BioPACIFIC MIP.

The key design capabilities of the BioPACIFIC MIP SAXS are:

- Multiple data collection modes to address a broad range of research needs, including SAXS, WAXS, GISAXS (grazing incidence SAXS), and GIWAXS.
- Tunable resolution and flux level depending on sample requirement.
- Custom designed Graphic User Interface optimized for high throughput workflow.
- Interface to a suite of environment stages (temperature, flow, etc.) for in-situ and time resolved studies.
- Modular architecture allows reconfiguration of the entire instrument when needed.

The many unique aspects of the BioPACIFIC MIP SAXS are a direct result of a modular architecture, which provides the flexibility to reconfigure the instrument to adapt to evolving research needs. Another important advantage of the custom designed platform is the ability to implement continual performance enhancements as new technologies become available. Most importantly, the open architecture enables the BioPACIFIC MIP research community opportunities to collaborate with the technical team to develop new SAXS and WAXS applications.

The SAXS is housed in the CNSI Building at UCSB (Elings 2419) and is overseen by Dr. Youli Li, who manages the X-ray Facility for the UCSB NSF MRSEC, and a research associate (Phillip Kohl).

HIGH-THROUGHPUT CHARACTERIZATION: SOFT MATERIALS AND RHEOLOGY

The High-Throughput Characterization Facility hosts and supports instrumentation for the structural, rheological, and mechanical characterization of materials, with a focus on high-throughput characterization. The available instrumentation includes an optical microscope with customized hardware and software, designed to serve as a first-in-class high-throughput automated microrheology tool for fluids and soft solids. Additionally, the facility is equipped with a high-throughput microindenter, which complements the microrheology tool by allowing for testing of materials much stiffer than possible with the microrheology tool alone. Furthermore, a versatile texture analyzer is available for linear and nonlinear mechanical measurements on solids.

Workflows: A custom incubator chamber mounted onto the motorized stage of the Zeiss Observer 7 microscope enables in vitro studies of cell attachment and migration across multiple manufactured materials. The incubator is designed to maintain homeostatic conditions for mammalian cell culture: 37 ºC ± 0.1 ºC, 5 ± 0.01 % CO_2, and >95 % RH. The incubator design modular and the chamber's temperature, gases, gas flow rates, and relative humidity can be fully controlled to accommodate a variety of biological samples and maintain bacterial, fungal, or embryonic homeostatic conditions.

The high-throughput characterization platform can be used to achieve simultaneous, in situ mapping of time-evolving morphology and microrheology in phase separating complex fluids over a large compositional space. For example, this method was applied to a canonical example of polyelectrolyte complex (PEC) coacervation, where mixing of oppositely charged species leads to liquid–liquid phase separation into distinct solute-dense and dilute phases (https://doi.org/10.1039/d1sm01763b). Morphology and rheology were measured simultaneously and kinetically after mixing to track the progression of phase separation. The relationships between composition and viscosity were extracted from the large datasets, predicting phase diagram boundaries that were independently validated by traditional thermogravimetric analysis (TGA), resulting in significant time and cost reductions in constructing a coacervate phase diagram.

The microrheology tool is housed in the CNSI Building at UCSB (Elings 2417). All other tools are housed at the Oasis facility near UCSB (71 S. Los Carneros Blvd.). All tools are overseen by Dr. Juan Manuel Urueña Vargas.

HIGH-THROUGHPUT CHARACTERIZATION: TRANSMISSION ELECTRON MICROSCOPY

The BioPACIFIC MIP facility for High-Throughput Transmission Electron Microscopy (HTTEM) endeavors to further develop the nascent technology of polymer (along with small molecule and protein) characterization using low-dose imaging, electron diffraction, diffraction tomography, and 4 dimensional scanning transmission electron microscopy (4DSTEM). The facility includes associated processes for sample preparation, data acquisition, and image analysis. The facility provides access to a state-of-the-art electron microscopy platform that enables fast and reliable structure determination of a variety of structures using microED, along with cutting edge phase imaging and 4DSTEM strain mapping.

The cornerstone technology for this facility, the ThermoFisher Scientific (TFS) Spectra 300 C-TWIN X-CFEG (Spectra 300C), is a state-of-the-art transmission electron microscope (TEM) specially designed for optimized electron diffraction. This first of its kind instrument takes the best tools from the cryogenic electron microscopy workflow and combines them with the array of tools developed for materials science imaging. This blend produces a microscope that can operate in many roles, focusing on diffraction and imaging of dose sensitive materials. The Spectra 300C's electron source is an X-CFEG (cold field emission gun) that makes the beam of electrons more wave-like (at synchrotron levels of brightness). In addition, the microscope is equipped with a three-condenser lens system, and a side entry stage for cryo-transfer double tilt operation during microED and cryo-4DSTEM experiments.

The Spectra 300C is equipped with a suite of detectors for both TEM and STEM. TEM mode, where a parallel beam of electrons illuminates the sample, uses the Ceta-D CMOS speed upgraded camera for high-resolution (sub-1Å) continuous rotation microED and scanning nanobeam electron-diffraction tomography (nanoEDT) data on dose-sensitive samples. A Falcon 3 camera is installed to provide single particle analysis imaging of non-crystalline samples. STEM mode, where a focused electron beam rasters

across the sample, uses a Panther STEM detector system with differential phase contrast (DPC), integrated DPC for phase detector (iDPC), and OptiSTEM+ for automated STEM alignments.

The microscope also offers semi-automated high-resolution STEM imaging performance at ultra-low fluences of beta radiation (1-100 electrons per angstrom squared) and energies from 30-300kV (alignments at 30, 60, 80, 120, 150, 200, and 300 kV). The X-CFEG allows for two Angstrom direct imaging resolution. The cryogenic capabilities of the Spectra 300C (cryobox and CTWIN pole piece) provide a reduction of ice buildup on the sample. This enables long working times at cryogenic conditions; conditions that are needed to provide protection to the most dose-sensitive samples.

The SAXS is housed in the CNSI Building at UCLA (CNSI B117) and is overseen by Dr. Matthew Mecklenburg.

DIGITAL ECOSYSTEM

BioPACIFIC MIP has developed and established a **Digital Ecosystem** to support the collection, cataloguing, curation, analysis, and sharing of data generated through both the platform's HT infrastructure and individual researcher contributions. The Digital Ecosystem currently comprises five distinct software-as-a-service (SaaS) web applications: a user portal (Portal), an electronic laboratory notebook (ELN), a laboratory information management system (LIMS), a materials library (Library), and the machine assisted product screening (MAPS) tool. The **BioPACIFIC MIP Portal** serves as the user's entry point to the Digital Ecosystem, giving users access to a singular sign-on and authentication service for all BioPACIFIC MIP SaaS applications. Via the Portal, users can access each of the BioPACIFIC MIP applications (ELN, LIMS, Library, MAPS). The **ELN** collects experimental notes, observations, methods, and protocols. It is designed to allow for free-form capture of information and functions much like a general-purpose text editor with specialized modules that assist with metadata collection and formatting, as well as digital parsing for other systems, like the LIMS. The **LIMS** is the primary data repository for BioPACIFIC MIP synthesis and characterization data, cataloging and storing instrument data uploaded to it, with annotations provided by the ELN. The **Library** is connected to the LIMS via a shared database and displays materials from the LIMS for users to browse. Approved users may also submit materials to the Library and upload basic information about available-upon-request library materials directly in the Library's User Dashboard. Lastly, the **MAPS** tool was built to identify monomers suitable for polymerization and leverage user-provided data for machine learning (ML) applications to provide insight for the prediction of chemical and material properties.

Alongside these web applications, BioPACIFIC MIP hosts the **BPM Wiki**, a Wikipedia-like application that contains information about the various characterization tools available to users in the MIP and provides descriptions and tutorials for the applications in the Digital Ecosystem. All applications are available for use by approved internal and external users as of April 2024. Planned enhancements for the Digital Ecosystem include: 1) improving user interfaces, 2) improving user experiences (e.g. improving performance and streamlining data entry processes), 3) expanding on-system features, 4) facilitating non-expert data access, and 5) integrating artificial intelligence (AI) tools to assist users in designing synthetic protocols.

Hardware: In support of the BioPACIFIC MIP computing activities, NVIDIA GeForce GTX 2080 GPU nodes for molecular simulations and NVIDIA research-class Tesla V100 GPUs have been added to existing infrastructure located at the Center for Scientific Computing (CSC) at UCSB (Elings Hall). These new processors will be equipped with hardware double-precision processing, large memory, NVLink for fast inter-GPU communication, enabling state-of-the-art field-theoretic simulations and machine learning

algorithms. The CSC is supported by both CNSI and the Materials Research Laboratory and is staffed by Dr. Paul Weakliem and Nathan “Fuzzy” Rogers.

4. IN-HOUSE RESEARCH

The BioPACIFIC MIP in-house research team is comprised of experts from a wide variety of disciplines including material science, chemical biology, chemistry, computer science, and mechanical engineering.

Position	Name	Inst.	Department	Major MIP Role
Director/PI	Javier Read de Alaniz	UCSB	CB	Director
Co-Director/PI	Heather Maynard	UCLA	CB/BE	Co-Director, SET 2 co-lead
Co-PI	Craig Hawker	UCSB	Materials/CB	SET 1 participant
Co-PI	Yi Tang	UCLA	ChE/CB	SET 1 co-lead
Co-PI	Rachel Segalman	UCSB	ChE/Materials /CB	SET 2 co-lead
Faculty	Chris Bates	UCSB	Materials	SET 1 co-lead
Faculty	Dino Di Carlo	UCLA	BE	SET 1 participant
Faculty	Paula Diaconescu	UCLA	CB	SET 1 participant
Faculty	Abigail Doyle	UCLA	CB	SET 1 participant
Faculty	Glenn Fredrickson	UCSB	ChE/Materials	SET 2 participant
Faculty	Miguel Garcia Garibay	UCLA	CB	SET 2 participant
Faculty	Mengyang Gu	UCSB	SAP	SET 1 participant
Faculty	Carrie Mills	UCSB	BE	SET 1 participant
Faculty	Aditya Nandy	UCLA	CBE	SET 1 participant
Faculty	Angela Pitenis	UCSB	Materials	SET 1 participant, Fellow Advisor
Faculty	Jose Rodriguez	UCLA	CB	SET 2 participant
Faculty	Scott Shell	UCSB	ChE	SET 2 participant
Faculty	Samanvaya Srivastava	UCLA	CBE	SET 1 participant, Fellow Advisor
Faculty	Megan Valentine	UCSB	ME	SET 1 participant
Faculty	Xifeng Yan	UCSB	CS	LLM/ELN integration

Key: BE: Bioengineering; ChE: Chemical Engineering; CB: Chemistry and Biochemistry; CBE: Chemical and Biochemical Engineering; CNSI: California NanoSystems Institute; CS: Computer Science; Materials: Materials Department; ME: Mechanical Engineering; SAP: Statistics and Applied Probability

A central unifying objective of the in-house research program is to advance the Materials Genome Initiative (MGI) paradigm by leveraging the MIP’s state-of-the-art high-throughput synthesis and characterization infrastructure in combination with advanced data analytics. These capabilities are applied to mission-driven challenges spanning sustainable materials and next-generation microelectronics, while also generating reproducible workflows, protocols, and datasets that are disseminated to the external user community.

Synthetic biology in the automated and high-throughput Living Biofoundry (focus at UCLA) will produce monomers with stereospecific functional groups from yeast, fungi and bacteria that will feed into an MGI based loop of hierarchical computation, automated polymerization and flow chemistry (focus at UCSB). Advanced characterization equipment suites (focus at both UCLA and UCSB) will be used to study polymers with high thermal stability, degradability, water solubility, printability, as well as stimuli-responsive polymers prepared using automated synthesis facilities (focus at UCSB).

New in this next phase of the MIP is a significant expansion in automated experimentation and materials processing, including the integration of in-line characterization, closed-loop control, and AI-enabled data analysis. This will be tightly integrated with structure-property relationship determination to guide molecular-level engineering and chemical formulation toward specific materials targets. A key goal is to provide an understanding of how bio-based materials assemble and carry out function. These activities are intentionally designed to generate shared, foundational knowledge at the interface of synthetic biology and material science.

5. USER PROGRAM

The primary mission of the BioPACIFIC MIP user program is to provide a broad, diverse community of researchers access to expertise, instrumentation, data libraries and materials libraries necessary to drive the discovery and production of novel bio-derived materials. BioPACIFIC MIP leverages a strong tradition of creating, operating, and maintaining open-access user facilities at UCLA and UCSB that enable transformative research. Acting as more than a suite of technical resources, BioPACIFIC MIP: (1) integrates internal, external, expert, and novice users alike into this mission of discovery, and (2) emphasizes intellectual capital, technical know-how, and a collaborative spirit in connecting users to tools and researchers.

The BioPACIFIC MIP facilities support several access modalities and project types. External projects, led by users outside of UCSB or UCLA, and Local projects, led by UCSB or UCLA faculty working outside of the BioPACIFIC MIP in-house research program, can be full research projects or sample/service requests. **Research projects** leverage multiple elements of the platform for material, pathway, or method development. Often, these projects involve multiple cycles through both BioPACIFIC MIP and the user's home institution. Projects usually involve a collaboration with the BioPACIFIC MIP project scientists and when required with BioPACIFIC MIP Faculty. The period of performance for BioPACIFIC MIP Research Projects is dependent on the scope of work but should nominally be completed within 1-year. Users are encouraged to come to BioPACIFIC MIP to carry out portions of the project, but are also facilitated by remote training, access, and instrument operation, as exemplified by the Spectra 4D STEM and Living Biofoundry. In-house research projects are similarly comprehensive, with a focus on providing students with training on the instrumentation to enable independent research. **Sample or service requests** are comprised of short-duration, limited-scope usage of single tools (e.g., SAXS, microED, biotage) or access to the BioPACIFIC MIP monomer, pathway, and data libraries. Users are welcome to come to BioPACIFIC MIP to carry out portions of the project, although typically the BioPACIFIC MIP staff synthesize new compounds or materials selected from the library or characterize materials sent to BioPACIFIC MIP. Projects involving **confidential research**, in which the user does not plan to share the data or materials with the BioPACIFIC MIP community or Local research that is not thematically connected to the BioPACIFIC MIP mission or otherwise without a merit-reviewed proposal may access the BioPACIFIC MIP facilities on a fee-for-use basis up to 10% of allocated instrument time in a 3-month period, provided the instrumentation has excess capacity.

Proposals are accepted on a rolling basis (sample requests, data requests, or research projects). It is strongly recommended that applicants first engage with the BioPACIFIC MIP leadership or User Coordinator to discuss the scope of the proposed work and proposal requirements. Users are expected to publish their work in a timely manner. Submission of data and/or materials may be made after publication or filing of IP through the appropriate channels, but within one year of the project's end date. Users must acknowledge the BioPACIFIC MIP award number (DMR-2445868) and the BioPACIFIC MIP name in all publications, presentations, websites, and press releases that are generated or resulting from BioPACIFIC

MIP in-house research and user projects. Users are also encouraged to mention specific instrumentation in the methods section of publications and in conference presentations.

PROPOSAL CONTENT GUIDELINES FOR PROSPECTIVE USERS

BioPACIFIC MIP Proposals are comprised of the following:

(1) Project Description, including references, addressing the items below if relevant (up to two-pages):

Intellectual Merit and Synergies

1. Motivation
2. Project Description or Sample Request Description
3. Desired outcomes and relevance, including products
4. What work will be performed at your home institution(s) to support the proposed project?
5. Description of quarterly technical milestones
6. Material needs and characteristics (*Only required for Sample Requests*)

Broader Impacts and Synergies

1. Knowledge to be contributed to the BioPACIFIC MIP community
2. Materials to be added to the BioPACIFIC MIP libraries (if any)
3. Data to be added to BioPACIFIC MIP databases
4. Collaborations with BioPACIFIC MIP Faculty/Staff/other (if any)
5. Collaborations with groups outside of BioPACIFIC MIP that may leverage the results of this work
6. Team, qualifications, and contribution to NSF/BioPACIFIC MIP diversity goals

(2) Two-Page NSF-style CVs for the Lead PI and Co-PIs.

(3) Graphical and written abstract for posting on the BioPACIFIC MIP website, should the project be approved.

PROPOSAL WORKFLOW

The workflow for dispositioning user proposals is shown in **Figure 3**.

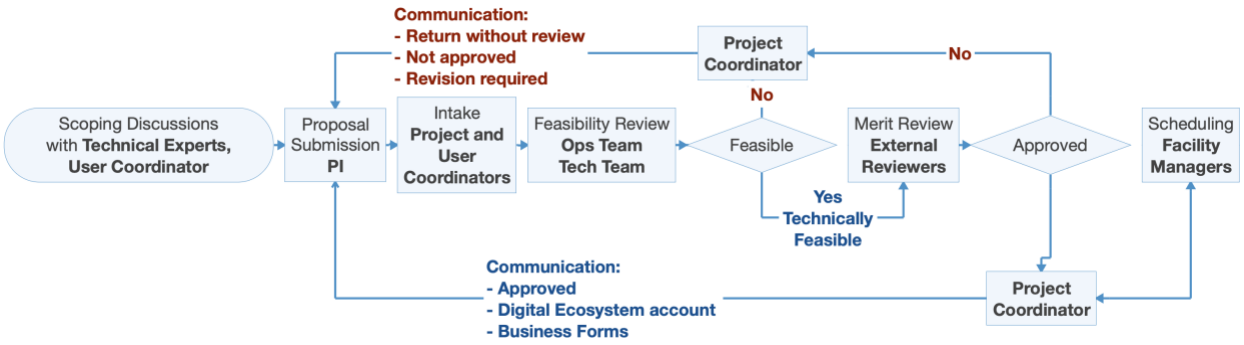


Figure 3: User proposal and sample request submission workflow. In-house research proposals follow the same workflow, with merit review conducted by the BioPACIFIC MIP leadership. The target timeline for approval is ≤4 weeks from proposal submission.

User proposals, sample requests, and Local proposals are submitted online through the BioPACIFIC MIP website. BioPACIFIC MIP proposals are uploaded as PDFs and should address the Intellectual Merit and Broader Impacts of the proposed project, as well as synergies with the BioPACIFIC MIP mission.

To assess the proposed project scope and feasibility, applicants also complete a short answer webform addressing questions specific to instrumentation that will be accessed, resources required, and potential safety hazards. This information is reviewed by the BioPACIFIC MIP technical team and is not part of the material provided to the external review committee.

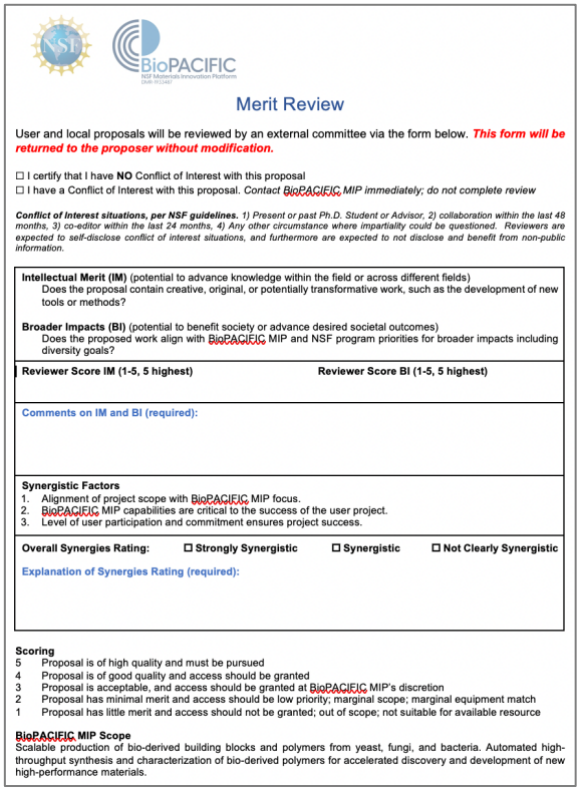
User proposals and sample requests are reviewed for merit by a rotating roster of scientific experts and BioPACIFIC MIP users from outside of UCSB and UCLA. The proposal review group includes academic faculty, staff, and industry researchers with expertise in disciplines ranging from synthetic biology, synthetic chemistry, materials characterization, and computation and data science. Individuals from this group review proposals as received.

MERIT REVIEW ROLES AND RESPONSIBILITIES

All proposals are reviewed for feasibility by the BioPACIFIC MIP technical team, the BioPACIFIC MIP User Coordinator, and the BioPACIFIC MIP Executive Directors. External user proposals, local user proposals, and sample requests are reviewed for merit by three external reviewers solicited from the broader community (outside of UCSB and UCLA). In-house research proposals are reviewed for merit by the BioPACIFIC MIP leadership.

MERIT REVIEW

External reviewers submit their feedback via a webform. To maintain the integrity of the process, reviews are received by 3 members of the BioPACIFIC MIP operations team (Tal Margalith, Adam Stieg, and Debbie Kleinpeter) and are also archived online. BioPACIFIC MIP has adopted a standardized review form (**Figure 4**) used by all four Materials Innovation Platforms that scores proposals for their Intellectual Merit and Broader Impacts criteria and provides a rating for Synergistic Factors. Proposers receive a copy of the reviewers' comments with the reviewers' identities redacted, but otherwise unmodified.



Merit Review

User and local proposals will be reviewed by an external committee via the form below. ***This form will be returned to the proposer without modification.***

☐ I certify that I have **NO** Conflict of Interest with this proposal
☐ I have a Conflict of Interest with this proposal. *Contact BioPACIFIC MIP immediately; do not complete review*

Conflict of Interest situations, per NSF guidelines. *1) Present or past Ph.D. Student or Advisor, 2) collaboration within the last 48 months, 3) co-editor within the last 24 months, 4) Any other circumstance where impartiality could be questioned. Reviewers are expected to self-disclose conflict of interest situations, and furthermore are expected to not disclose and benefit from non-public information.*

Intellectual Merit (IM) (potential to advance knowledge within the field or across different fields)
Does the proposal contain creative, original, or potentially transformative work, such as the development of new tools or methods?

Broader Impacts (BI) (potential to benefit society or advance desired societal outcomes)
Does the proposed work align with BioPACIFIC MIP and NSF program priorities for broader impacts including diversity goals?

Reviewer Score IM (1-5, 5 highest) **Reviewer Score BI (1-5, 5 highest)**

Comments on IM and BI (required):

Synergistic Factors
1. Alignment of project scope with BioPACIFIC MIP focus.
2. BioPACIFIC MIP capabilities are critical to the success of the user project.
3. Level of user participation and commitment ensures project success.

Overall Synergies Rating: ☐ **Strongly Synergistic** ☐ **Synergistic** ☐ **Not Clearly Synergistic**

Explanation of Synergies Rating (required):

Scoring
5 Proposal is of high quality and must be pursued
4 Proposal is of good quality and access should be granted
3 Proposal is acceptable, and access should be granted at BioPACIFIC MIP's discretion
2 Proposal has minimal merit and access should be low priority; marginal scope; marginal equipment match
1 Proposal has little merit and access should not be granted; out of scope; not suitable for available resource

BioPACIFIC MIP Scope
Scalable production of bio-derived building blocks and polymers from yeast, fungi, and bacteria. Automated high-throughput synthesis and characterization of bio-derived polymers for accelerated discovery and development of new high-performance materials.

Figure 4: Proposal review form

FOR ACCEPTED PROPOSALS

The User Coordinator informs the proposal PIs of the committee's decision. PIs of accepted proposals will work with the User Coordinator on scheduling logistics for any travel to UCSB and/or UCLA. Financial aid

for travel and housing is available to researchers from non-R1 universities. The PI and co-PIs of each funded proposal are required to sign and accept the BioPACIFIC MIP Policies, including intellectual property, confidentiality, acknowledgements, and data and material retention. These policies are posted on the BioPACIFIC MIP website.

Prior to commencing research, the users (PIs, co-PIs, and project researchers) are asked to register through the user portal managed by the BioPACIFIC MIP evaluation team. As shown in **Figure 5**, users also complete online laboratory safety training and submit facilities use waivers and agreements. Industry users are required to submit standard business information forms to address insurance and billing requirements. All forms are posted for review on the BioPACIFIC MIP website. The project researchers are added to the online laboratory management systems (FBS) so that BioPACIFIC MIP can track equipment usage, supplies and consumables, and access to other shared-use facilities at UCSB and UCLA.

Per the MIP PTC, user fees will be charged for work leveraging unused equipment capacity, exploratory research, or confidential research. Campus-approved rates are posted on the BioPACIFIC MIP website.

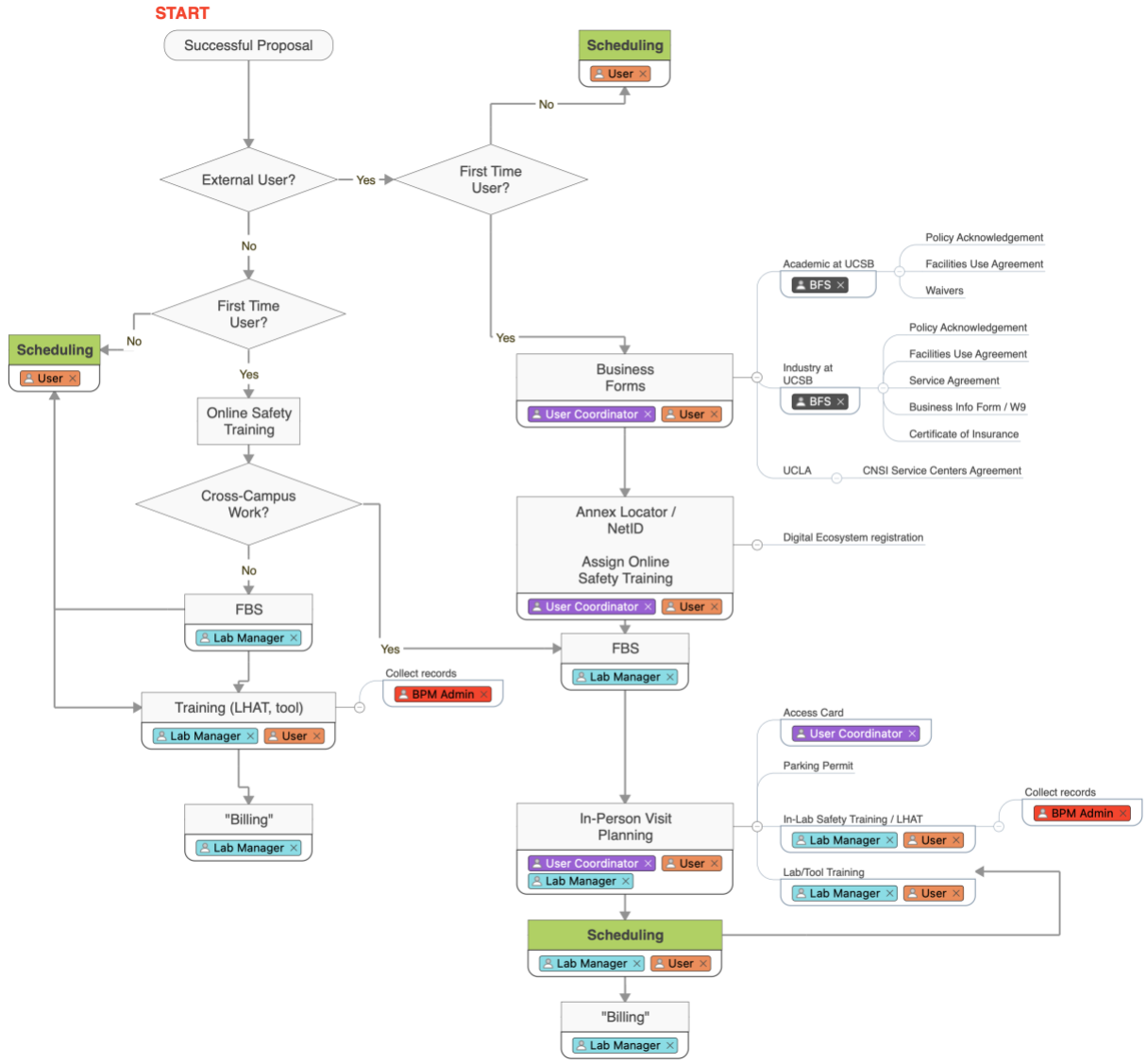


Figure 5: User onboarding workflow.

Users are expected to publish their work in a timely manner. Submission of data and/or materials may be made following publication or filing of IP through the appropriate channels, but within one year of the project's end date. The User Coordinator communicates with each project team quarterly to solicit updates and highlights for Knowledge Sharing.

Since communication, contextualization, and acknowledgement of the how BioPACIFIC MIP resources enable results helps prospective users understand how they might advance their research by joining the community, the full acknowledgement guidelines promote BioPACIFIC MIP's knowledge sharing and growth. Researchers working on **approved user projects** or **in-house research** at BioPACIFIC MIP are requested to:

- Mention BioPACIFIC MIP within the main body of publications, in the methods section or where the facilities or procedures are described; example: "SAXS measurements were performed at the BioPACIFIC MIP user facilities at UC Santa Barbara."
- Include the BioPACIFIC MIP logo and mention the relevant instrumentation when describing experimental methodologies in conference presentations and posters.

and required to:

- Acknowledge both the BioPACIFIC MIP award number (DMR-2445868) and the BioPACIFIC MIP name in all publications that are generated or resulting from BioPACIFIC MIP in-house research and BioPACIFIC user projects, including through use of the BioPACIFIC MIP funded tools, materials, or data in person or virtually; example: "This work was supported by the BioPACIFIC Materials Innovation Platform of the National Science Foundation under Award No. DMR-2445868."
- Acknowledge the BioPACIFIC MIP award number (DMR-2445868) and/or BioPACIFIC MIP name in all presentations, websites, press releases, etc. that are generated or resulting from BioPACIFIC MIP support under the Materials Innovation Platforms solicitation (NSF 25-521).

For users accessing the facilities through the **recharge/fee mechanism**:

- The BioPACIFIC MIP award number (DMR-2445868) must be acknowledged in all publications that are generated or resulting from BioPACIFIC MIP support under the Materials Innovation Platforms solicitation (NSF 25-521), including use of the BioPACIFIC MIP funded tools, materials, or data in person or virtually.
- The BioPACIFIC MIP award number (DMR-2445868) and/or BioPACIFIC MIP name must be acknowledged in all presentations, websites, press releases, etc. that are generated or resulting from BioPACIFIC MIP support under the Materials Innovation Platforms solicitation (NSF 25-521).

A brief explanatory video on how to acknowledge BioPACIFIC MIP is posted on the BioPACIFIC MIP website (https://youtu.be/tG5wSCXTSDw).

6. CROSS-CUTTING ACTIVITIES/GOALS – EDUCATION, TRAINING, AND KNOWLEDGE TRANSFER PROGRAMS

EDUCATION AND TRAINING

The BioPACIFIC MIP education program aims to bridge the gap between industrial needs and academic education to increase the workforce pipeline with a diverse pool of highly educated and effective scientists well-prepared to contribute, through a variety of career tracks, to innovations in biomaterials.

BioPACIFIC MIP Trainees

BioPACIFIC MIP trainees will be immersed in a community of researchers, engaging in transdisciplinary biomaterials research training, collaboration, career preparation, and mentorship within a network of academic and industry professionals.

The training experience will include:

- Training in BioPACIFIC MIP research and facilities via quarterly 2-day training modules and throughout their graduate school/postdoctoral career.
- Regular All-SET meetings.
- Career guidance via talks at quarterly All-Hands meetings, Individual Develop Plan (IDP) creation and the “Whole PhD: Developing Your Professional Self” online series
- Industry input at All-Hands meetings
- Science Communication competitions (speed pitch, graphical abstract)
- Peer-peer, community and leadership networking, and mentorship with industry and academic professionals through regular meetings and quarterly All-hands meetings.
- Access to $500 travel grants for BioPACIFIC MIP related professional travel.

BioPACIFIC MIP Summer School

The BioPACIFIC MIP Summer School will offer a week-long opportunity for students, postdocs, faculty, and research staff to learn about discipline fundamentals as well as industry needs. Instructors will include BioPACIFIC MIP faculty and industry researchers versed in the BioPACIFIC MIP equipment and industrial counterparts.

The summer school will focus on:

- High-throughput research, automation, and the industrial research approach
- Theory behind specific BioPACIFIC MIP research elements, DBTL experimental design, and the MGI approach
- Hands-on workshops on key instrumentation and techniques including the Living Biofoundry, the robotic synthetic chemistry platform, microED, and more
- Serving as both a training mechanism and recruitment tool for users

The summer school is open to the broad BioPACIFIC MIP community. Attendees travel to California and couple hands-on experience and experimentation with the instructional component. Lodging and food costs are covered for all participants. Financial aid is available to participants from non-R1 institutions to support travel.

KNOWLEDGE SHARING STRATEGIES

The BioPACIFIC MIP facilities serve as an interdisciplinary research nexus that promotes a culture of knowledge sharing through collaboration and scientific discourse. The significant investments in these facilities are carefully managed and staffed with technical experts that impart knowledge through hands-on interaction with users, thus expanding and evolving the MIP's institutional knowledge base. This research infrastructure provides the foundational framework to sustain and strengthen the future impact of the BioPACIFIC MIP, with the scientific community benefiting from expert knowledge, shared methods, and unique materials. BioPACIFIC MIP continues to envision sharing as a two-way flow of information through a collaborative partnership with the users: users bring new knowledge to the MIP while also learning from it. This knowledge sharing is essential for the long-term sustainability and impact of this enterprise.

BioPACIFIC MIP exercises several tiers of communication strategies to promote knowledge sharing for all stakeholders, including regular All-Hands meetings, bi-weekly technical SET meetings, and an annual User meeting (**Figure 6**). BioPACIFIC MIP will continue to focus on strengthening the integration of knowledge sharing and the development of the Digital Ecosystem and drive the development of workflows that enable the soft materials community to adopt high-throughput methodologies, which integrate automated experimentation with data mining and machine learning, for discovery and workforce training.

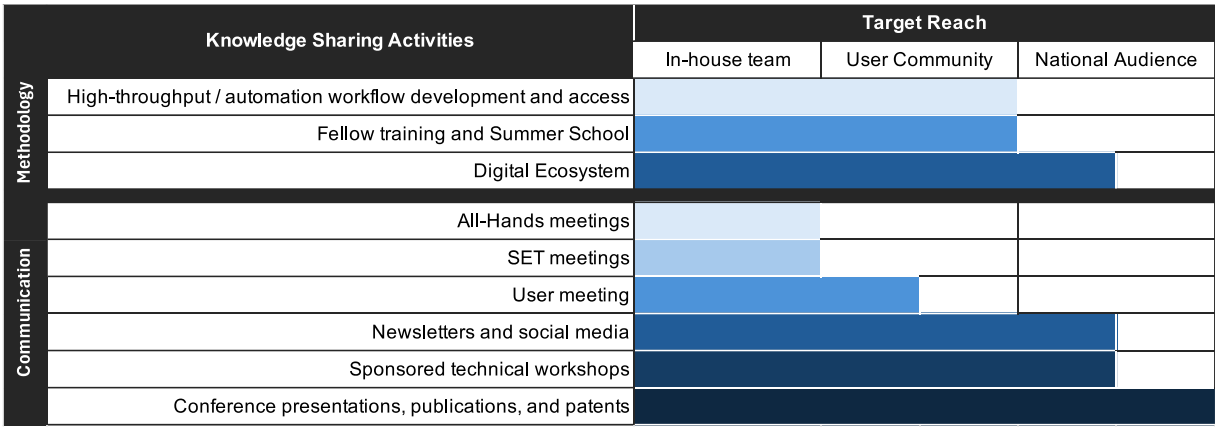


Figure 6: BioPACIFIC MIP knowledge sharing activities carried out in the initial funding period and to be continued in the next 5 years.