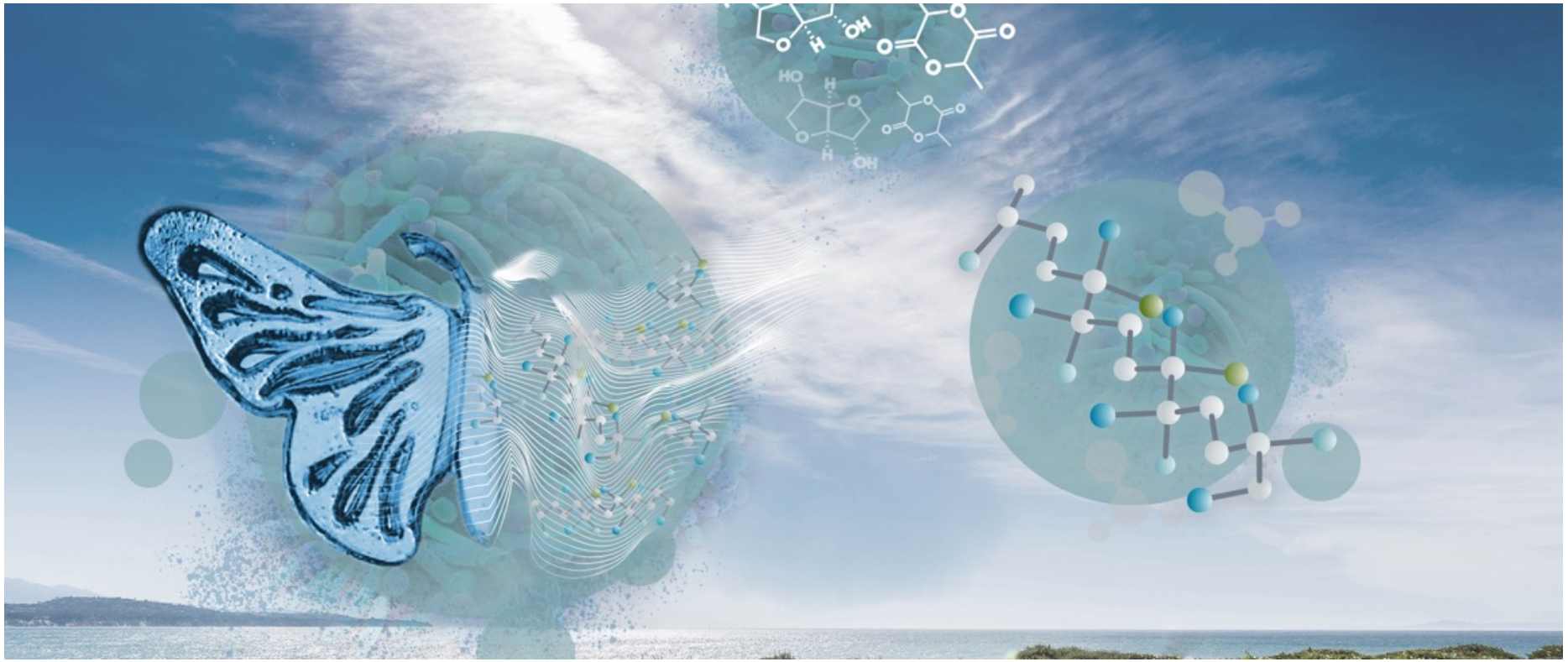


Sign up to stay informed at **biopacificmip.org** or at **http://eepurl.com/hcOERz**

Agenda

1. What Makes MIPs Unique
2. BioPACIFIC Overview
3. Education and Associate Training
4. Questions

NSF BioPACIFIC Materials Innovation Platform

Collaboration between UCSB and UCLA – $23.7 M over 5 yrs.

Establishes **first user-facility in the nation** that combines automation and high-throughput experimentation in synthetic biology and material synthesis for **biomaterial development and discovery**

MIPs are Unique

Materials Innovation Platform (MIP)

A unique mid-scale infrastructure program in NSF Division of Materials research

Tool development	User facility	In-house research	Training
Develop next-generation experimental and computational tools to advance discovery and development of new materials	Operate a user facility that provides unique materials research tools, samples, data, and technical services open to diverse community	Conduct in-house research to address a grand challenge in material science	Serve as an educational focal point for training the next generation of tool developers and users

- At least **50% of the overall MIP time allocations** goes to **external user projects** based on competitive proposals nationwide

- **At least 10% of the overall MIP time allocations goes to non-R1 universities, including HSIs and HBCUs.**

BioPACIFIC MIP Operations Overview

Tal Margalith
Exec Dir. UCSB

Adam Stieg
Exec Dir. UCLA

Morgan Bates
Project Scientist UCSB
Synthesis and Automation

Positions Available

User Coordinator:	**Hiring open**	UCSB
Research Scientists:		
- MicroED	**Hiring open**	UCLA
- Living Bioreactor	**Hiring open**	UCLA
Computation/DS:	**Hiring open**	UCSB
Process Engineers:	**To be hired**	UCSB (1), UCLA (1)

BioPACIFIC Careers

Nature Has Provided Us With Remarkable Materials

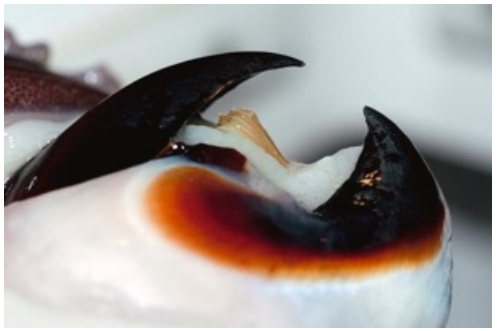
Strong

Source: iStockphoto

Hydrophobic

Source: Science Photo Library

Tough



Source: Louise Murray

Adhesive

Source: Shutterstock

Camouflage

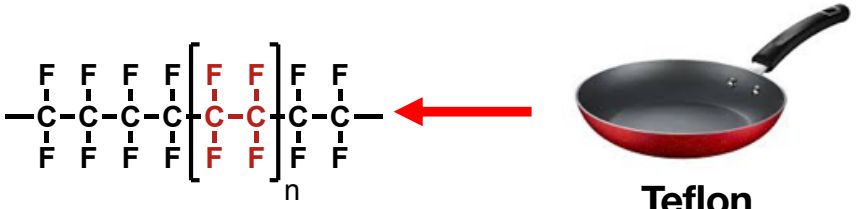
Source: Monterey Bay Aquarium

Eco-Friendly

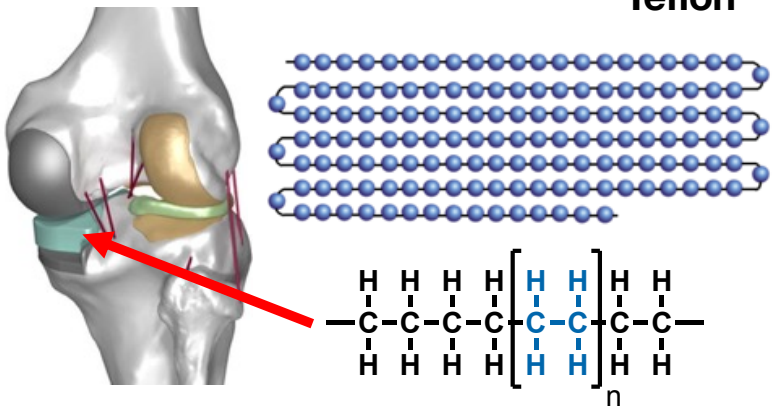
Source: iStockphoto

Designing Materials Using Biological Building Blocks

Synthetic building blocks



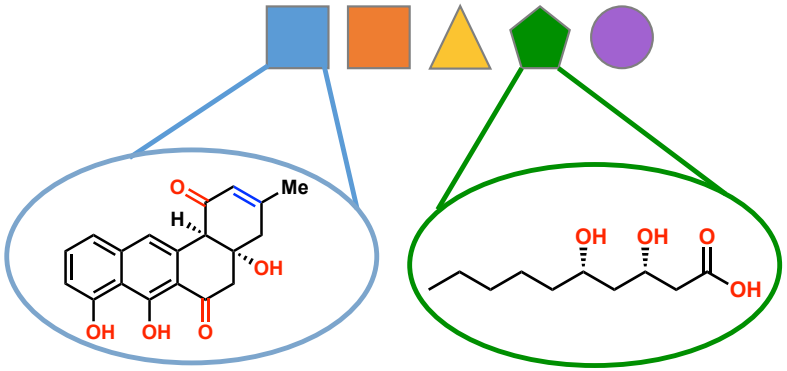
Teflon



Ultra high molecular weight polyethylene

- Performance not at full potential
- Environmental impact is huge

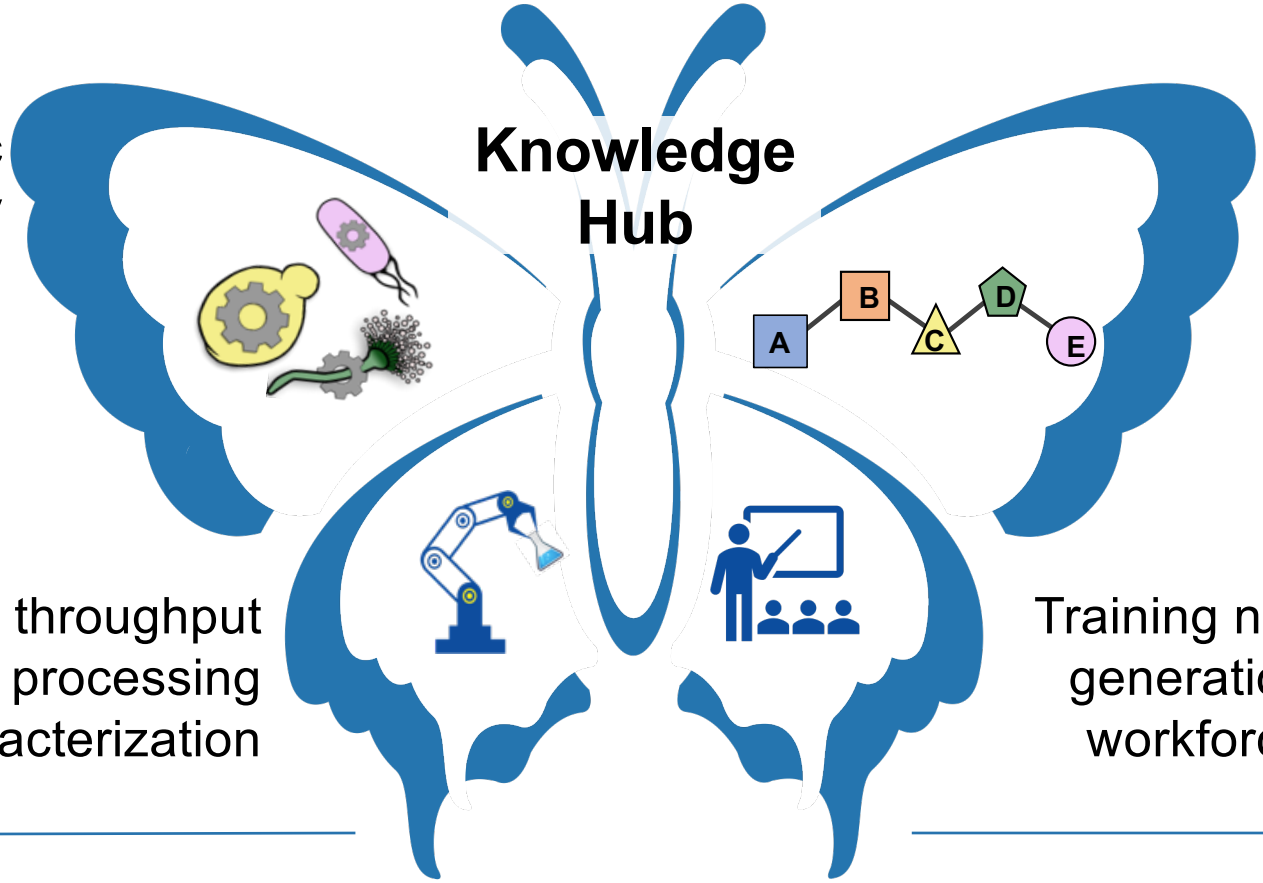
Nature's building blocks



High functionality **Chiral**

- Remarkable breadth of properties
- Multi-functional and dynamic

BioPolymers, Automated Cellular Infrastructure, Flow, and Integrated Chemistry: Materials Innovation Platform (BioPACIFIC MIP)



Team

Computation and Data


Glenn Fredrickson **Co-lead**


Scott Shell **Co-Lead**


Ambuj Singh


Fuzzy Rogers


Paul Weakliem


Tobias Hollerer


Irene Chen


Jun Park

Synthetic Materials


Hosea Nelson


Dan Morse


Megan Valentine **Lead**


Angela Pitenis


Yang Yang


Michelle O'Malley


Yi Tang **Lead**


Yang Hai


Todd Yeates


James Bowie


David Valentine

Synthetic Biology

Characterization


Ellen Sletten


Heather Maynard **Co-Director**


Jose Rodriguez

Additive MFG


Elliot Hawkes


Yon VIssel


Craig Hawker **Lead**

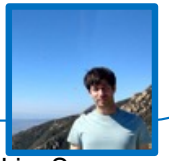

Javier Read de Alaniz **Director**


Tim Deming


Rachel Segalman


Matt Helgeson


Chris Bates


Lior Sepunaru


Songi Han

Operations and Education


Dave Bothman


Tal Margalith **Exec. Director**


Morgan Bates **Project Scientist**


Adam Stieg **Exec. Director**


Arica Lubin


Rita Blaik


Youli Li


Wendy Ibsen

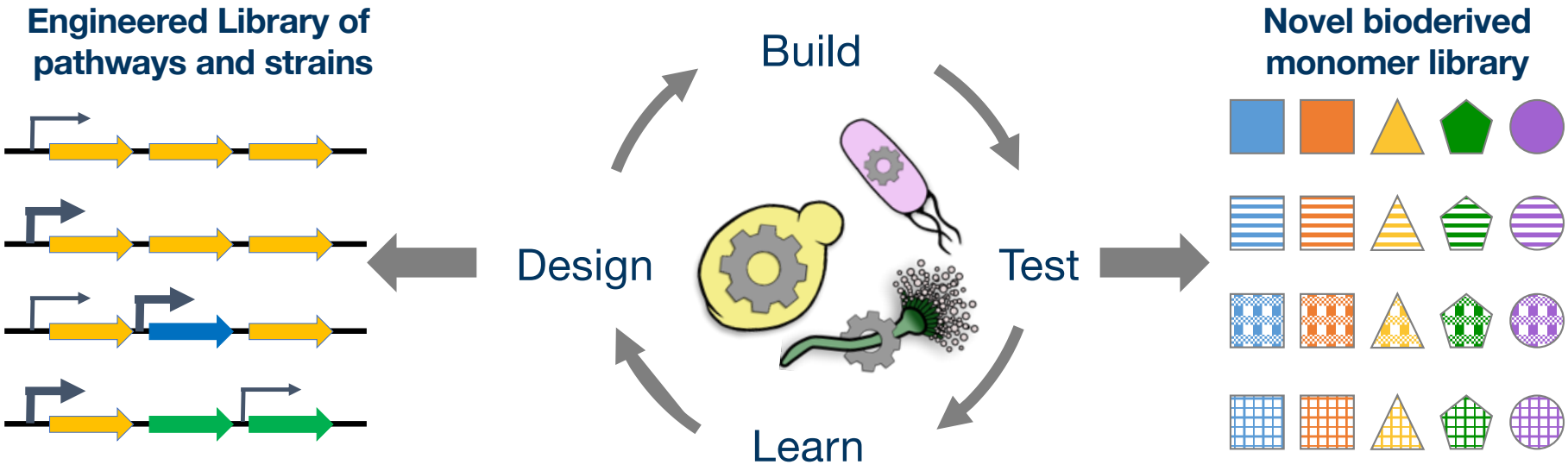
= UCSB

= UCLA

BioPACIFIC

Opportunity To Greatly Expand Material Properties

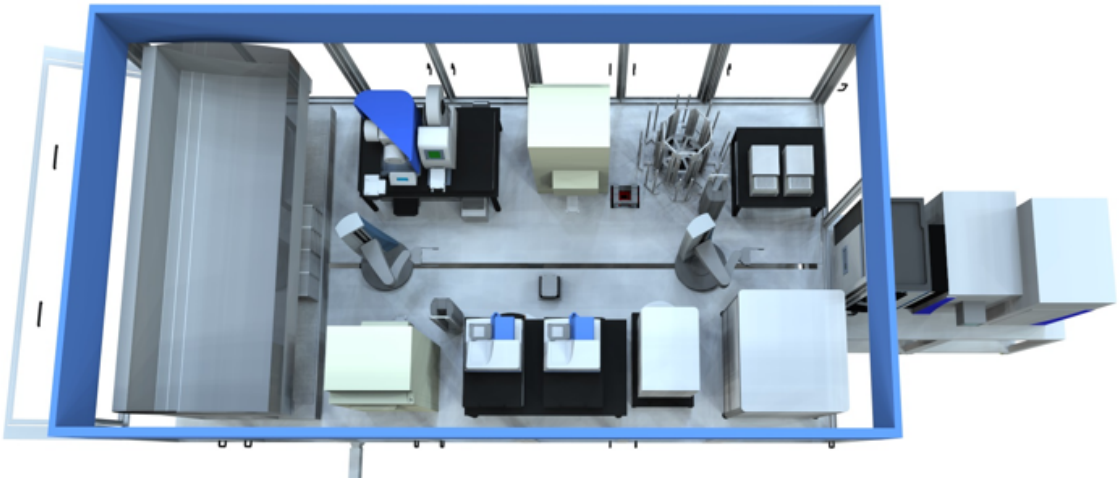
Synthetic biology offers tremendous advantages as a **sustainable** source to create a vast array of **novel compounds**



Engineer biological systems to discover, optimize and produce new monomers and to develop and apply new cell-based polymerization

Synthetic Biology Infrastructure

Acquisition: Automated synthetic biology suite + inline characterization



ThermoFisher Synthetic Biology Automation System

- Integrated, automated workflow accelerates the DBTL cycle from 1 sample-per-week to >500 samples-per-week:
  - Microplate robot, automated incubators, reagent dispenser, thermal cycler, plate sealer, carousels/racks

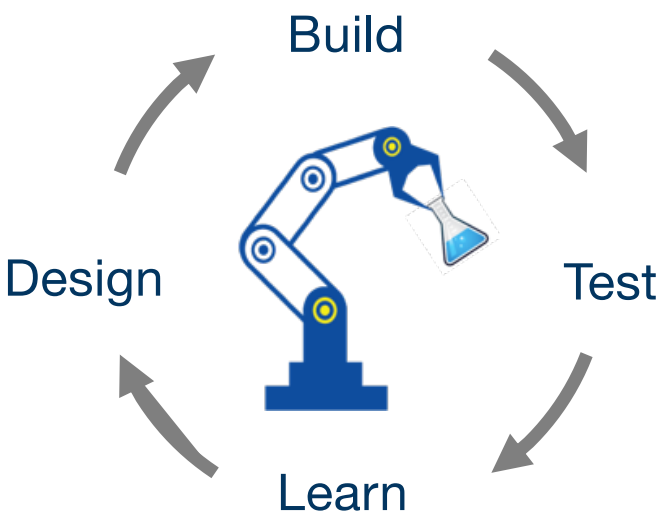
TSQ Altis MS w/ Vanquish Flex UHPLC

- Inline triple quadrupole UHPLC/MS/MS
- 5-2000 m/z mass range w/ Active Ion Mgmt
- 6 channel high-pressure solvent blending

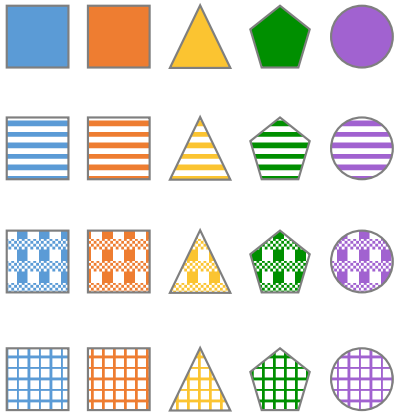
Estimated Arrival: Summer 2021 **Hiring**: Project scientist – Open

Opportunities: Rapid Development, Access and Training

High throughput robotic platform



Monomer library



Bioderived + bioinspired synthetic monomers

- Next generation workforce will be trained in **data-driven synthesis**
- Modernizing the way we process and formulate polymers
- BioPACIFIC users will be able to do research **faster** and **safer**

Material Synthesis Infrastructure

Acquisition: Suite of high-throughput synthetic platforms + inline characterization tools

Estimated Arrival: Fall 2021

Chemspeed Synthesis Platform

- Automates library synthesis using ATRP, ROMP, RAFT, and photo-controlled polymerizations
- Parallel synthesis reactors for photo-, high-pressure, high and low-temperature reactions
- Robotic transfer arms and dispense tools automate reaction preparation, work-up, and centrifugation
- Performs all benchtop manipulations (filtration, evacuation, degassing, stirring, etc.) with minimal-to-no user intervention

Material Synthesis Infrastructure

Acquisition: Suite of high-throughput synthetic platforms + inline characterization tools

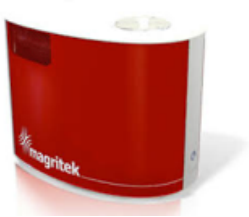
Available: Spring 2021

Gyros Symphony X Peptide Synthesizer

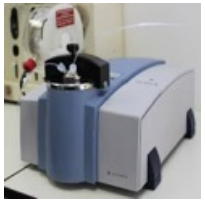
- Automates peptide, peptoid, and solid-phase syntheses in parallel (>12 reactions)
- Enables access to large material quantities (2 grams resin per reaction vessel)

Vapourtec Flow Chemistry System

Available: Spring 2021



Magritek NMR

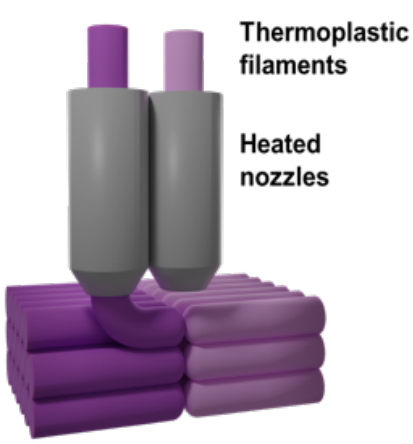


Mettler Toledo Flow FT-IR

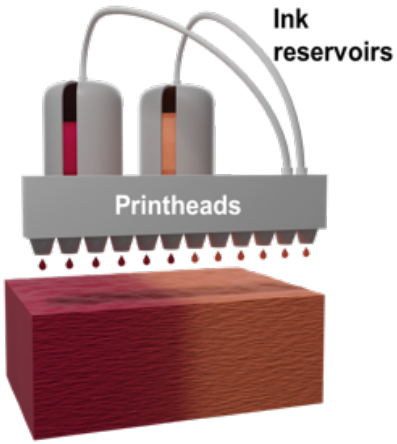
- Automates reaction optimization using in-line characterization and brings reactions to scale
- Features electrochemical, photochemical, high- and low-temperature reactors

Additive Manufacturing Infrastructure

Acquire a suite of 3-D printing technologies for applications in a range of biomaterials

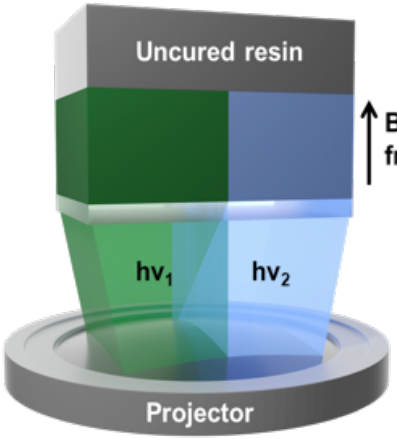


Fused filament modeling
Solidified by cooling



Material jetting
Solidified by UV exposure

novel resins

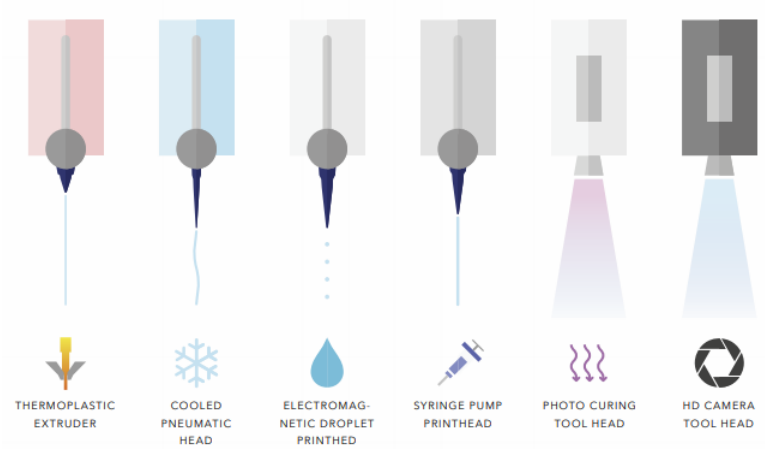


SMaLL
Solidified by visible light

novel strategy - SMaLL
novel resins

Dave Bothman
CNSI microFluidics

Cellink BioX Extrusion Printer

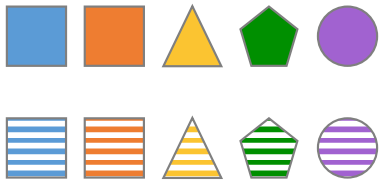


- Easy material integration (custom made and commercial ink)
- 7 Exchangeable print head for modular functionality
- **Temperature print bed:** 4-60 ºC
- **Print Resolution:** 1 µm
- **Advantage:**
  - Print living cells
  - Support different resin system with different gelation stimuli

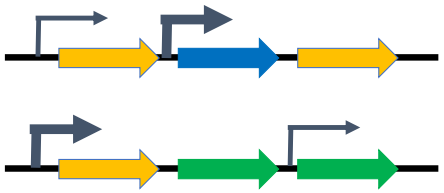
(Available: Winter 2021)

Democratizing Big Data

Bioderived + bioinspired synthetic monomer **Libraries**

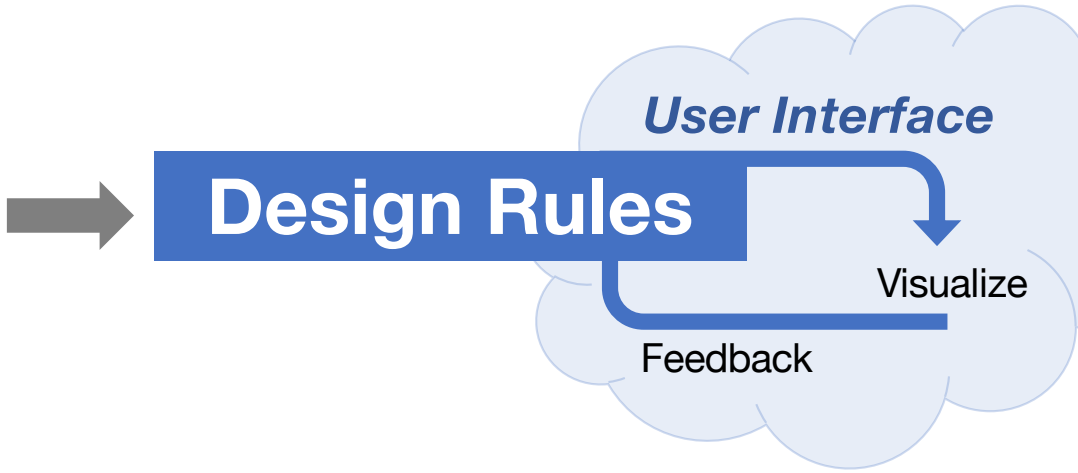


Pathways Engineering **Libraries**



+

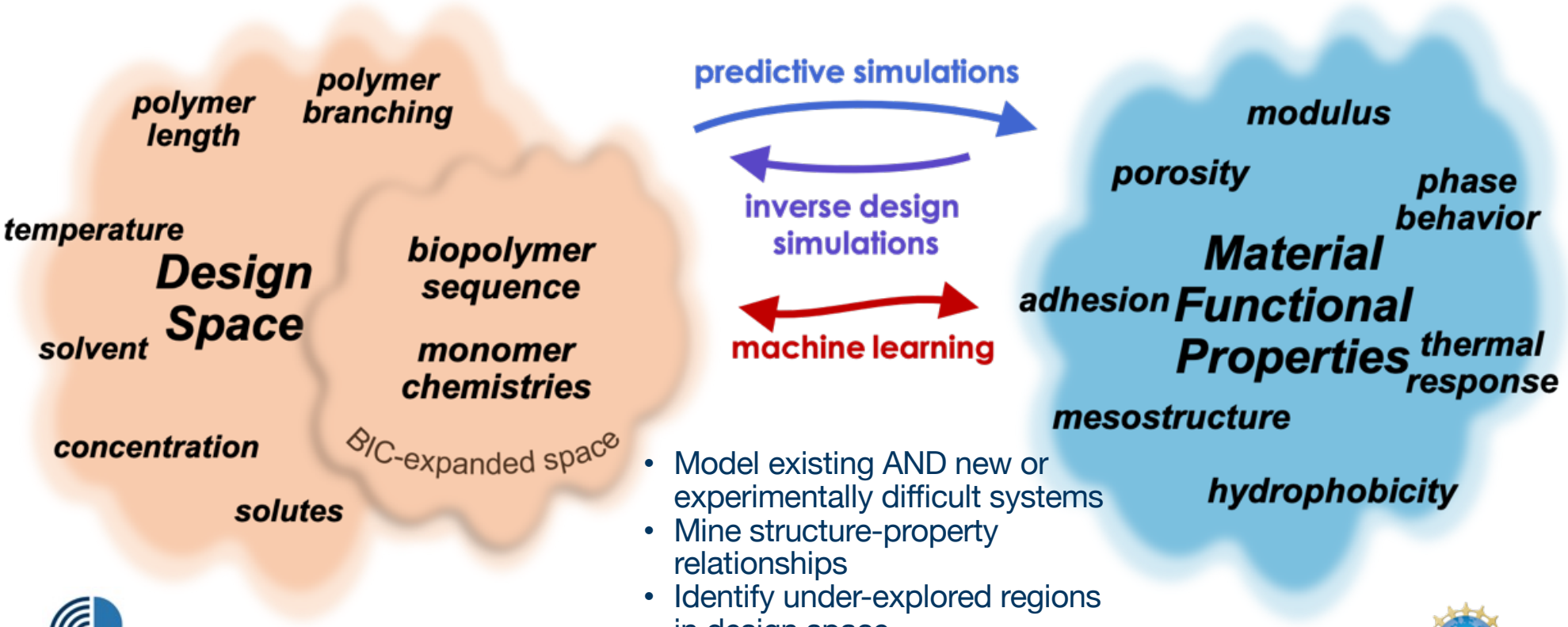
Automated workflow
(control and record temp, pressure, time, extra)



BioPACIFIC automation workflow will enable users to access and build libraries and design rules

Computation to Chart Expansive Design Spaces

Vision: Versatile tools to enable systematic mapping of design space



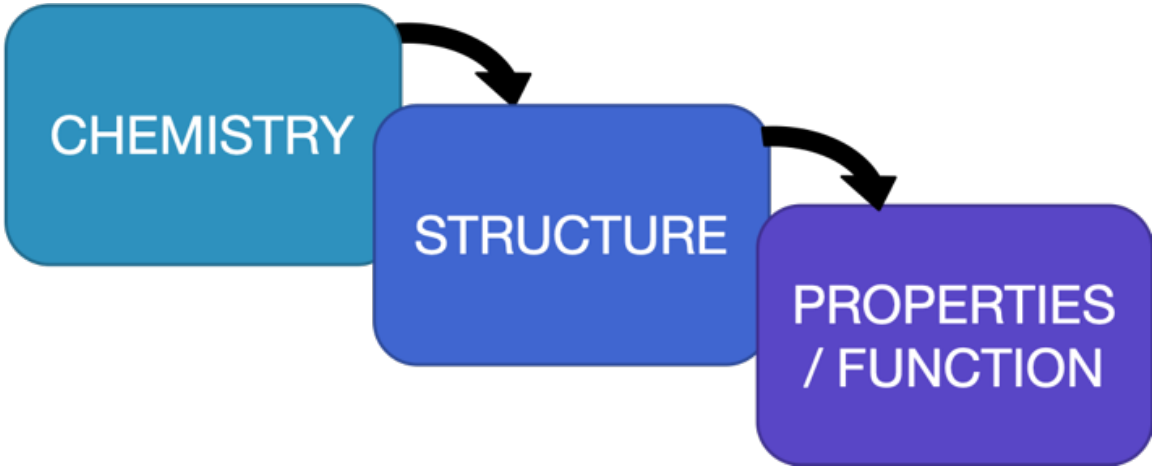
- Model existing AND new or experimentally difficult systems
- Mine structure-property relationships
- Identify under-explored regions in design space

Hierarchical Computation Tools

Staff Paul Weakliem and Fuzzy Rogers

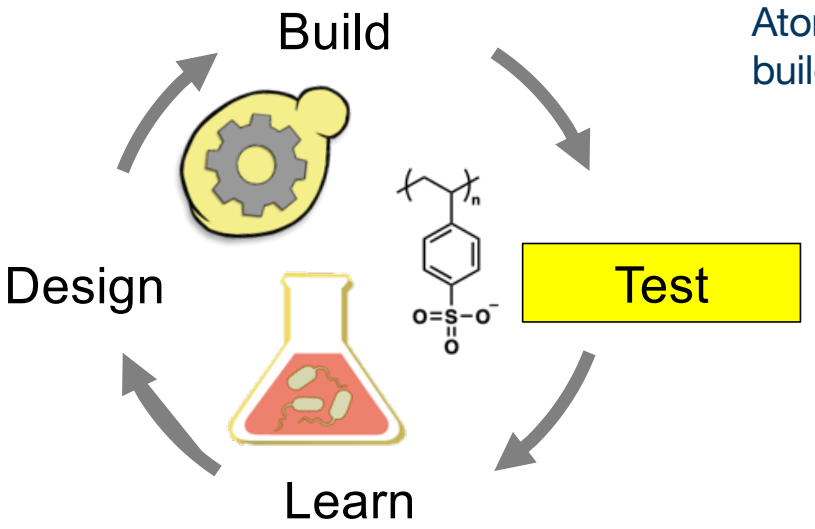
Hierarchical computational tools

- predictive materials modeling across scales
- inverse computational design
- machine learning of structure-property relationships from both simulation and experimental data



Structure-Property Platform

Vision: Structure-Property Platform will establish relationship that inform development of predictive models to guide the design and synthesis of material targets



High-resolution analysis:

Atomic scale characterization of (sub-)micro crystals of building blocks to identify structure-property relationships

Intermediate scale analysis:

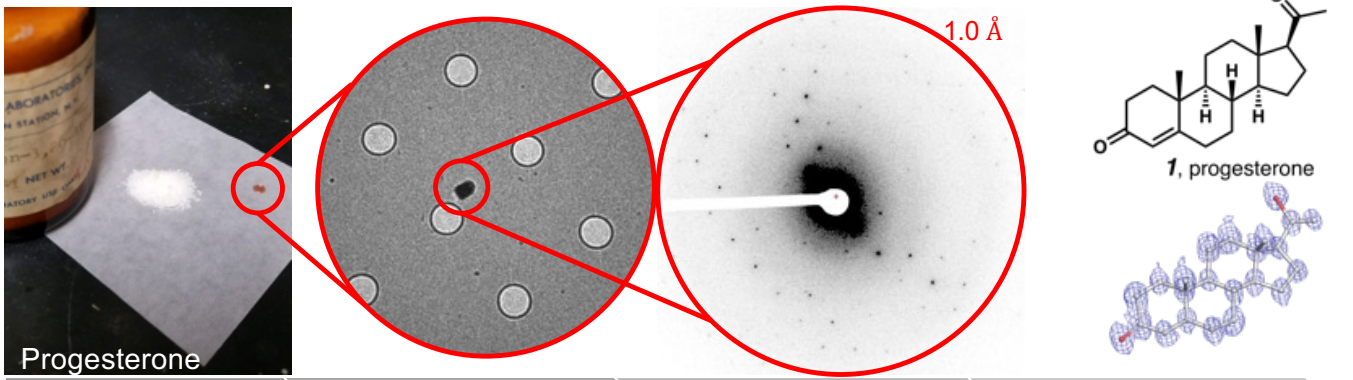
Advanced analysis of structural organization in identified building blocks at mesoscopic length scales (5-500 nm)

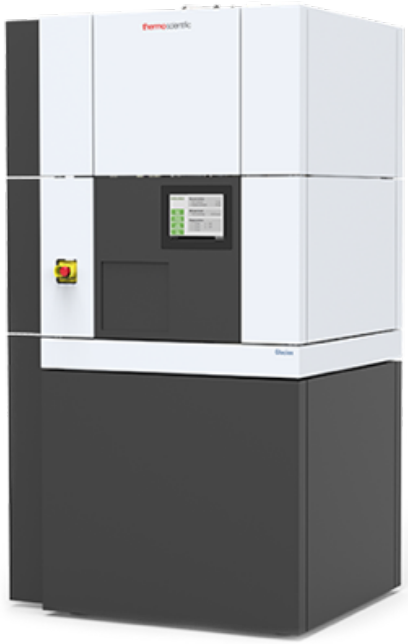
Rapid analysis and down-selection:

Feature selection of biomolecular building blocks that provide targeted material properties

MicroElectron Diffraction (microED)

Acquisition: Enables rapid, atomic scale characterization of biomolecular materials





ThermoFisher (FEI) Spectra-C TEM

- First-of-its-kind TEM configured for microED & 4D STEM
- X-CFEG (cold field emission gun) with low dose exposure
- Wide gap C-TWIN lens enables +/- 70 degree tomography
- Cryo-transfer holder and automatic cryo-box
- Advanced scripting for automated data collection

Estimated Arrival: Fall 2021

Hiring: Project scientist – Open

X-ray Scattering (SAXS-WAXS)

Youli Li
MRL X-ray

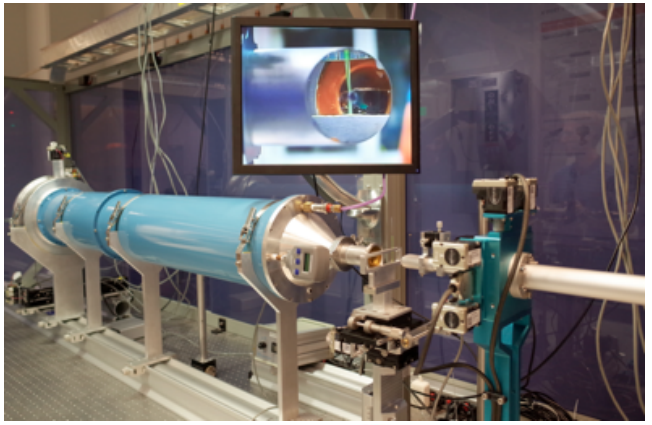
Utility: Broad application for intermediate scale characterization (0.1nm-100nm) of nanoparticles and macromolecular assemblies

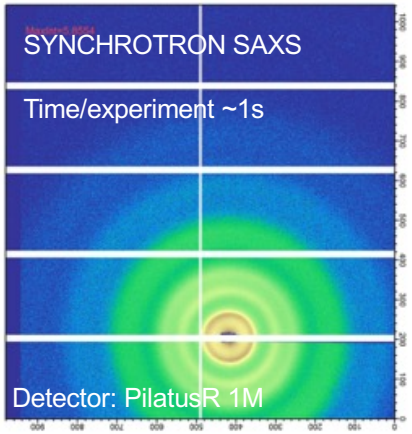
Acquisition: high-brilliance x-ray source and large area photon counting detector

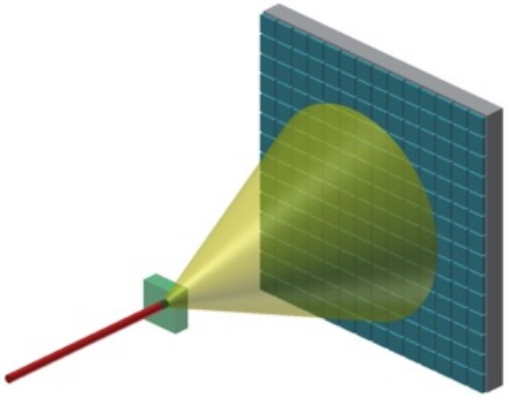
Impacts: >100% boost in measurement throughput with improved resolution

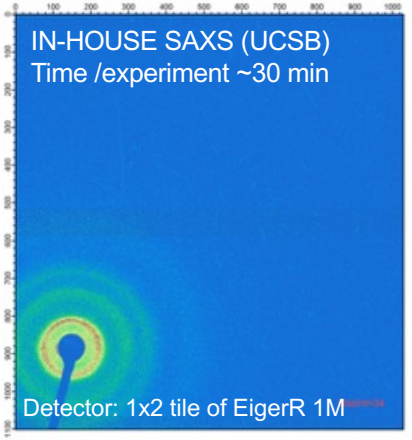
- ~10X increase in beam flux
- ~4X increase in detector area

Estimated Completion: Fall 2021





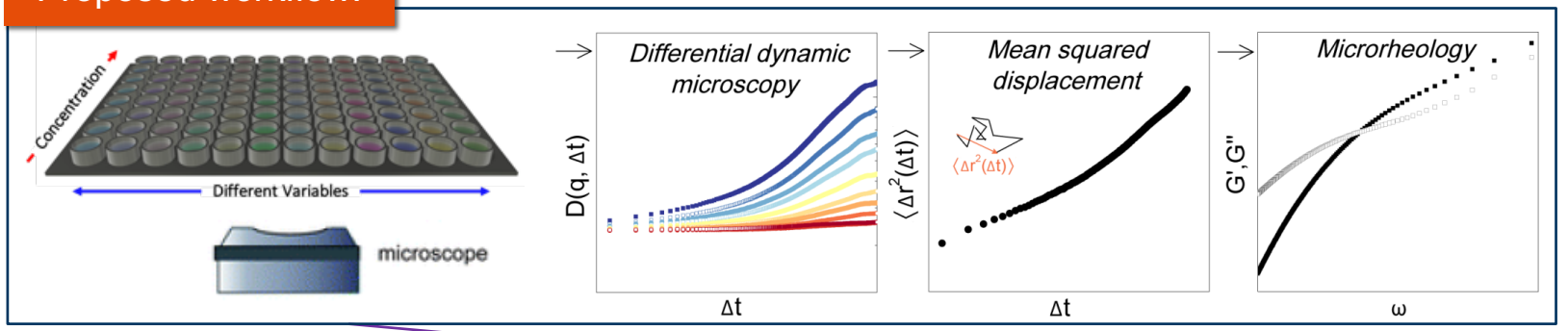




Microrheology

Development: Passive, high-throughput method for automated microrheology

Proposed workflow:



Experimental Design
- *Sample composition*
- *Solution conditions/history*

→ Data acquisition
~ 1 min/sample

→ Data analysis
~ 1 min/sample

→ Rheological data
In a matter of minutes

Experimental design feedback

Estimated Completion: Spring 2021

Impact: Increases throughput by 30X for data acquisition and 60X for analysis while **dramatically relaxing the restrictions on the sample**

Shared Facilities at UCSB and UCLA

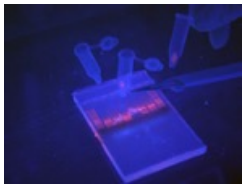
Home About People Platform User Program Research Education News Events

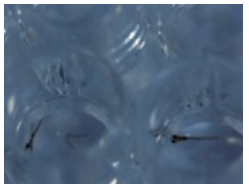
Platform | Instrumentation | Facilities | Expertise | Materials Design

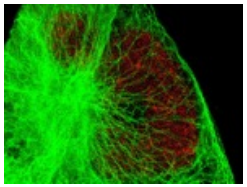
BioPACIFIC MIP Facilities

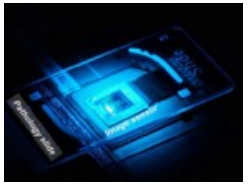
The BioPACIFIC MIP User Community can leverage a number of Shared-Use Facilities at each campus.

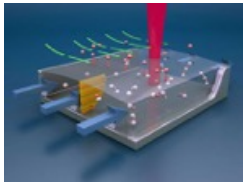
Institution - Any - Apply




Become a User:
BioPACIFIC MIP Proposal Based Process

User Proposals

1. PROPOSAL SUBMISSION	2. FEASIBILITY REVIEW	3. MERIT REVIEW	4. EXECUTION

- Rolling submissions
- Service requests or in-person research
- **Recommend discussing scope with technical team and directors before submission**
  - Submit Contact Request form at https://biopacificmip.org/users/new
- Proposal submission via online portal on website
- **For awarded proposals users are NOT charged for time with technical staff, supplies, or for use of equipment acquired through the MIP award.** *Fees charged for proprietary research*

User Proposals

1. PROPOSAL SUBMISSION	2. FEASIBILITY REVIEW	3. MERIT REVIEW	4. EXECUTION

- In-house review
- Resource assessment
  - Equipment
  - Staffing
  - Materials
  - *50% external users at steady-state

User Proposals

1. PROPOSAL SUBMISSION	2. FEASIBILITY REVIEW	3. MERIT REVIEW	4. EXECUTION

- **External committee**
- Key criteria:
  - Alignment with BioPACIFIC mission
  - Growth of knowledge hub / libraries
  - Intellectual Merit
  - Broader Impacts / Diversity

User Proposals

1. PROPOSAL SUBMISSION	2. FEASIBILITY REVIEW	3. MERIT REVIEW	4. EXECUTION

- Policies and Forms
  - https://biopacificmip.org/users/policies
- Travel logistics (as applicable)
- Scheduling
- **Funding available to enhance diversity of participation**

Education of BioPACIFIC Fellows and Associates

Training in BioPACIFIC research

Career guidance via talks at quarterly meetings and

Professional skills workshops: collaboration, trans-disciplinary innovation, communicating across disciplines, understanding industry needs, etc.

Peer-peer networking through monthly and quarterly meetings and summer workshops

Community and leadership networking and mentorship with industry and academic professionals through speed networking events and mentorship map training

Professional Development

Peer to Peer Networking

Apply here:

or at https://biopacificmip.org/education

Summer School: Training Users and a New Workforce

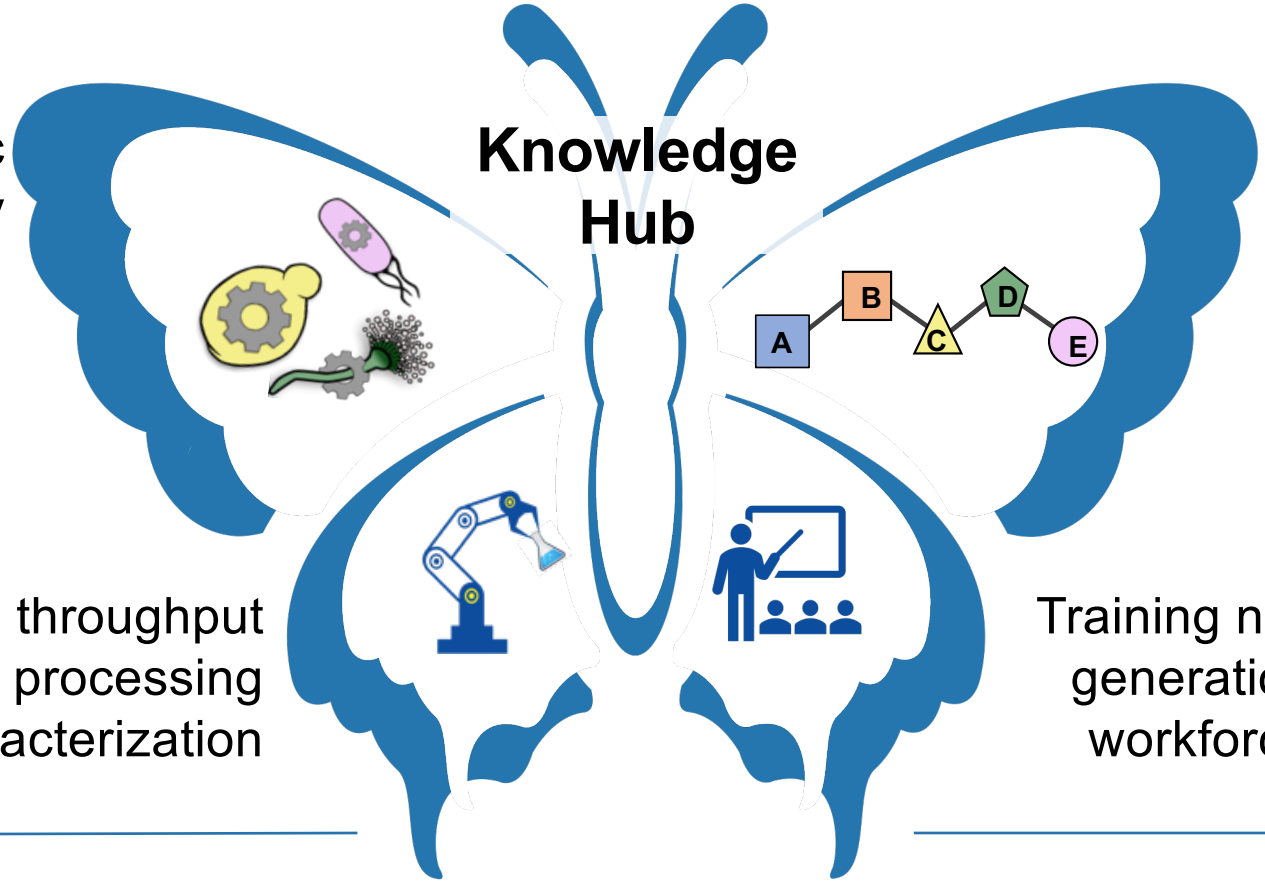
- High-throughput research / **industry mentality and needs**
- Theory behind specific BioPACIFIC research elements and **DBTL experimental design**
- Opportunity to bring and **run experimental samples**
- **Industry participation** and multi-directional mentorship
- Serves as both a **training mechanism and recruitment tool** for a diverse user cohort
- **BioPACIFIC scholarships** for external users to enhance diversity of participants


Lubin


Blaik

This year the school will be virtual

BioPolymers, Automated Cellular Infrastructure, Flow, and Integrated Chemistry: Materials Innovation Platform (BioPACIFIC MIP)



Questions?

Instrument Development and Acquisition

Available to Users	Fall 2020	Winter 2021	Spring 2021	Summer 2021	Fall 2021
Synthesis Instrumentation	Prep HPLC	Flow chemistry Protein synthesizers		Automated Platforms for Synthetic Biology and Chemical Synthesis	Batch reactors Microwave synthesis
Characterization and Property Determination		Analytical LC-MS React IR In-situ 60 MHz NMR	Micro-rheology	MicroED	SAXS/WAXS
Additive Manufacturing		SMaLL Platform Bioprinter (Cellink BioX or Allevi-3)			Multi-material printer
Computing	Nodes				

Next Steps

- **Sign up** to stay informed at **biopacificmip.org** or at **http://eepurl.com/hcOERz**

- **Participate in Teaming Think Tanks**:
  - Lunch and Learn talks by Element Leads – Starting the week of September 28th, date/time TBD
  - Topics examples –
    - Biopolymer synthesis and use of click chemistry to build biopolymer (**Wednesday Sept 30th, 12-1 pm)**
    - Automated synthetic biology spinnaker system
    - 3D printing of orthogonal materials using SMaLL
    - Tutorial on MicroED and potential use for materials
    - MicroRheology and its use for quantitative mechanical analysis of soft solids and complex fluids
    - Computational tools for prediction of material properties
    - Machine learning of structure-property relationships: merging simulation and experimental data
- **Develop proposal**
  - Scoping discussions with Heather or Javier
  - Submit proposal that leverage existing core facilities while MIP tools are developed and acquired

- **Recruit external users**

Backup slides

Proposal-Based Access – per NSF PTC

- Each MIP-funded tool shall be used **mostly** by users through successful competitive proposal mechanism and for in-house research.
- **Exceptions** to the competitive proposal review requirement may exist for:
  - Hands-on training workshops*
  - Proprietary research (paying full cost recovery)*
  - Utilizing extra capacity (paying user fee)*
  - Other special cases at the MIP Director's discretion such as brief feasibility studies.*

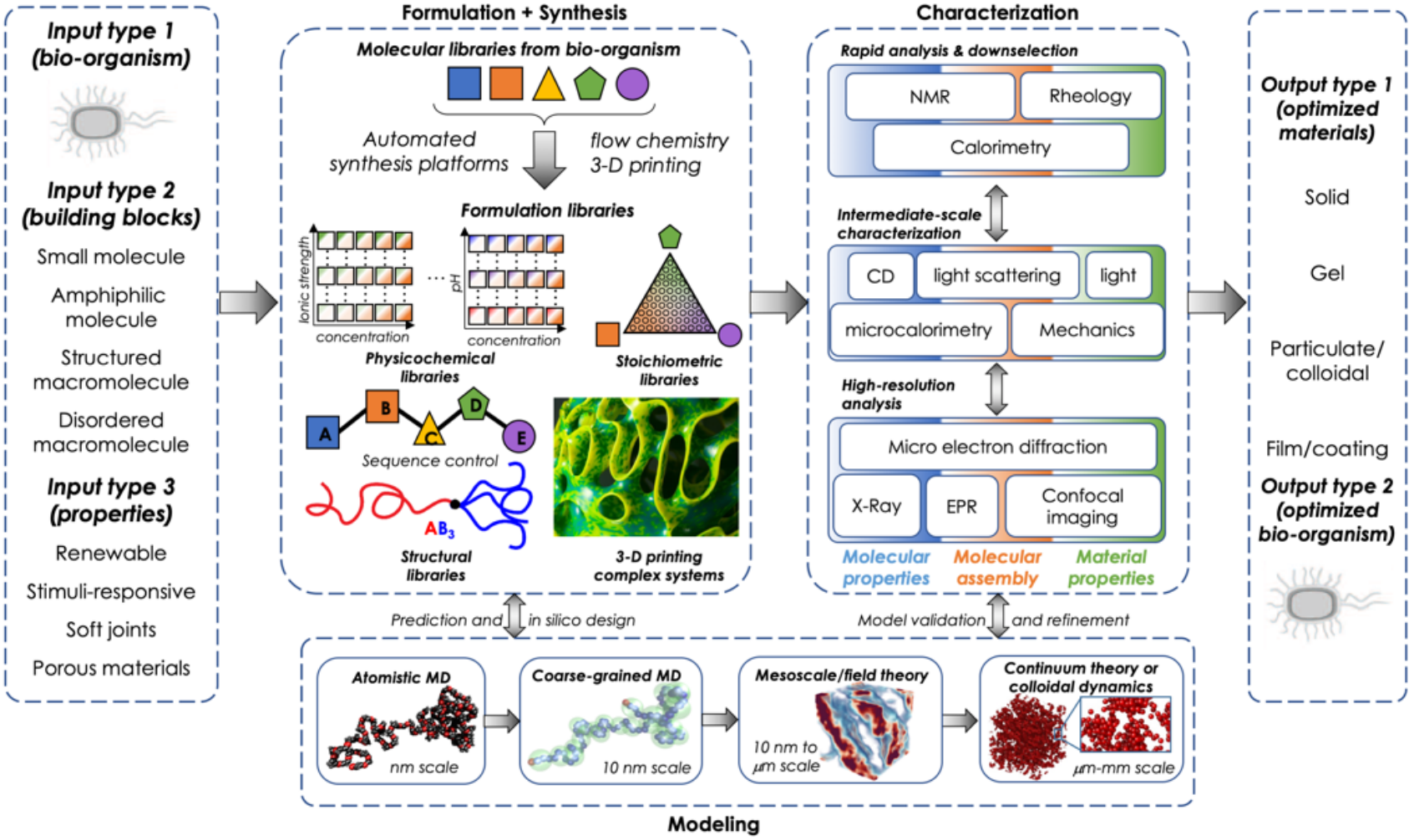
Time-Based Allocations – per NSF PTC

- At least **50% of the overall MIP time allocations goes to external user projects** based on competitive proposals nationwide.
- **No more than 50%** of the overall MIP time allocations goes to the in-house research and local user projects.
- At least 10% of the overall MIP time allocations goes to **user projects in non-R1 universities**, including MSIs.
- Up to 10% of the overall MIP time allocations can go to **exploratory topics** beyond the MIP scope.
- Time allocation calculations will be based on actual usage time of instruments purchased/developed/paid-for using the MIP funds.
- *The percentage allocations above are for **steady-state operation (Years 3-5)***

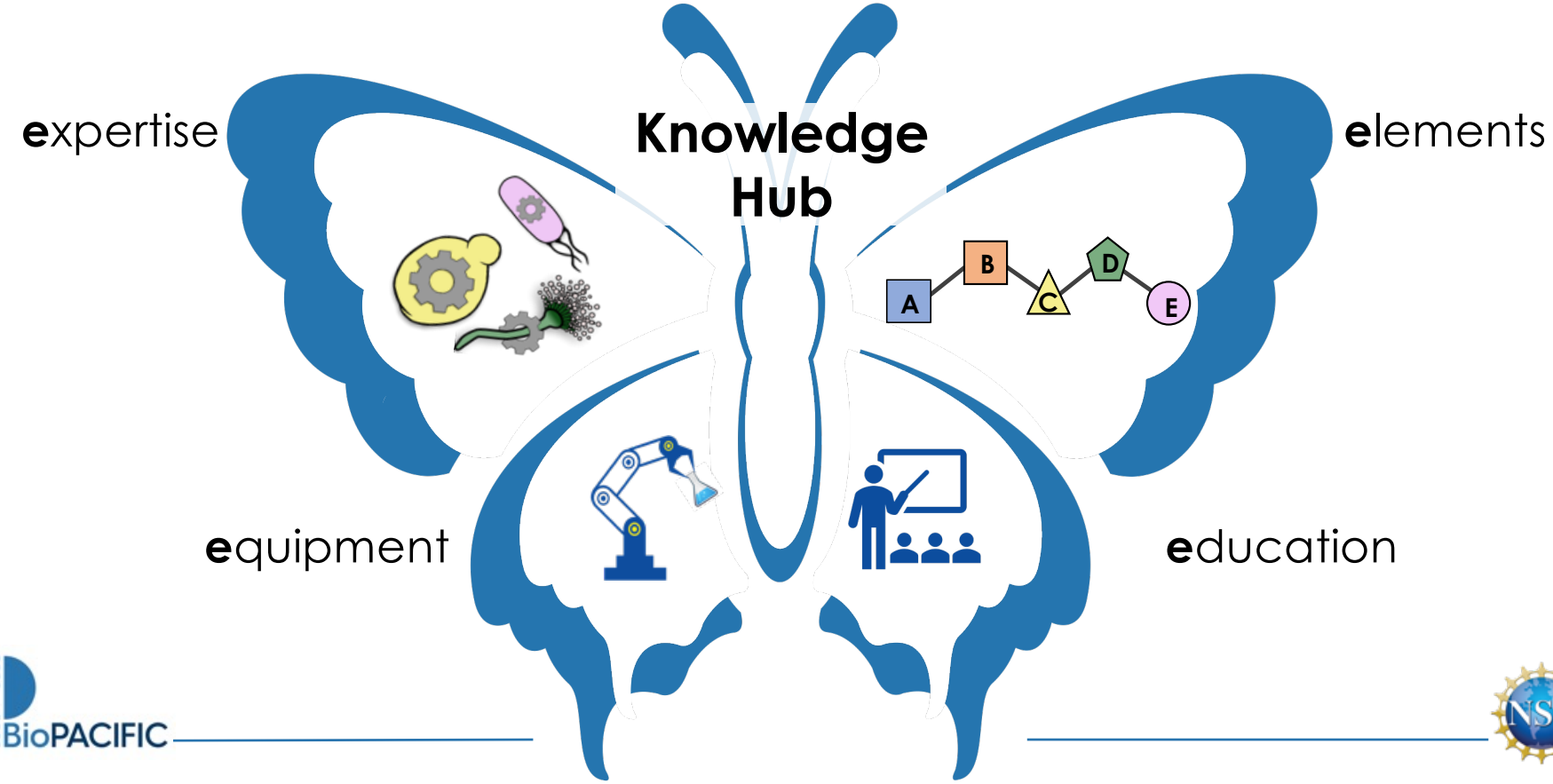
BioPACIFIC MIP

Building from nature to invent and develop advanced materials that put us on a path toward a more sustainable future

Vision of Complete Flexible BioPACIFIC Workflow



e⁴: Keys to Success for BioPACIFIC



BioPACIFIC MIP Operation

th QR code

Operations Overview

Tal Margalith
Exec Dir

Adam Stieg
Exec Dir / UCLA UC

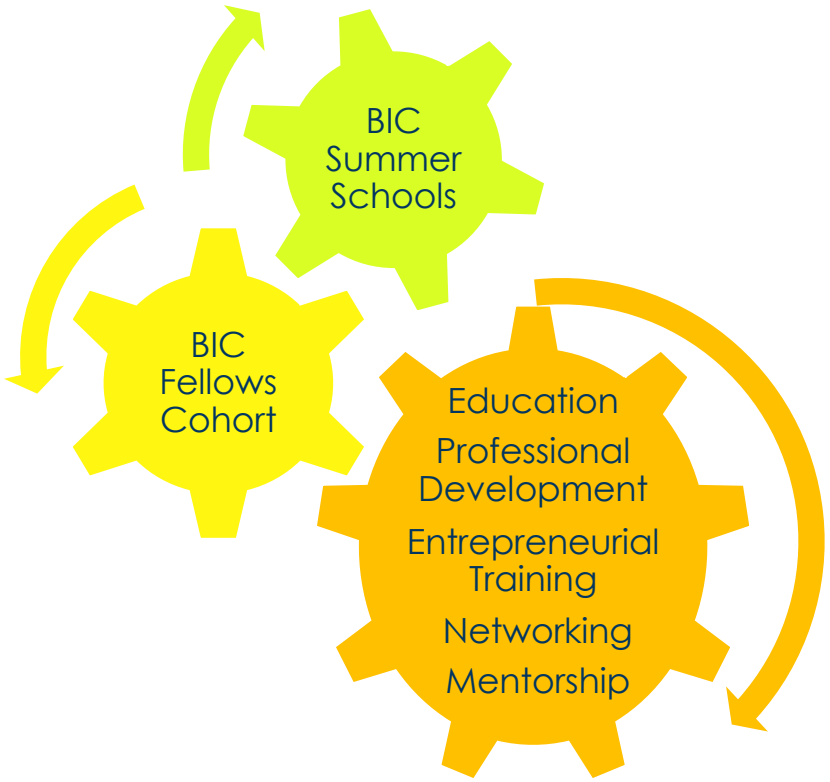
User Coordinator:	To be hired	UCSB
Research Scientists:	To be hired	UCSB (2), UCLA (2)
Process Engineers:	To be hired	UCSB (1), UCLA (1)
Computation/DS:	To be hired	UCSB

Mission:

- Engage users at all expertise levels in discovery of new bioderived materials
- Establish the BioPACIFIC MIP as a hub for knowledge creation, access, and dissemination

BioPACIFIC MIP Education and Training

Vision for Education and Training



Workforce trained in high-throughput experimental design and closed-loop innovation

Goal: Bridge the gap between industrial needs and academic education to increase the workforce pipeline with a diverse pool of highly educated and effective scientists

BIC Summer School: Training Users and a New Workforce

- High-throughput research / **industry mentality**
- Theory behind specific BIC research elements and **DBTL experimental design**
- Opportunity to bring and **run experimental samples**
- **Industry participation** and multi-directional mentorship
- Serves as both a **training mechanism and recruitment tool** for a diverse user cohort
- **BIC scholarships** to enhance diversity of participants


Lubin


Blaik

5 “Themes”
(to keep in mind; slide won’t be included)

1. This is the only center which will merge work on Synthetic Biology with Materials Synthesis within the Materials Genome Initiative approach
2. We have funding opportunities for in-house research
3. We’re establishing a research eco-system based on infrastructure investment and broadly-accessible materials, pathways, and data libraries
4. We are training a new student workforce in high-throughput experimental design
5. MIPS are unique NSF mid-scale infrastructure programs