Materials Innovation Platforms (MIP)

Webinar for MIP Solicitation NSF 25-521

2:30 pm – 4:00 pm EST, January 14, 2025

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Program Directors

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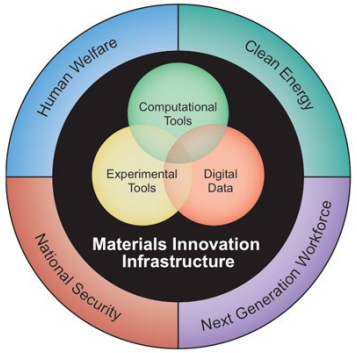
Agenda

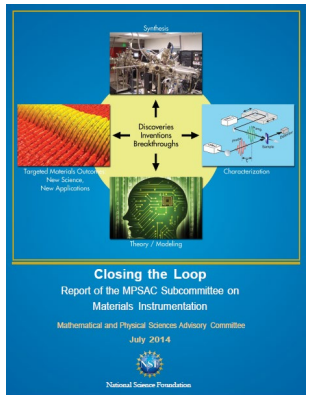
- The MIP Program
- Two previous MIP competitions and four existing MIPs
- The upcoming third MIP competition
  - Research topic
  - Eligibility and limitations
  - Major changes
  - Budget guidance
  - Timeline
- Review criteria

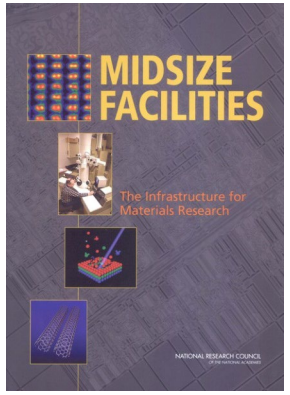
- Questions and answers

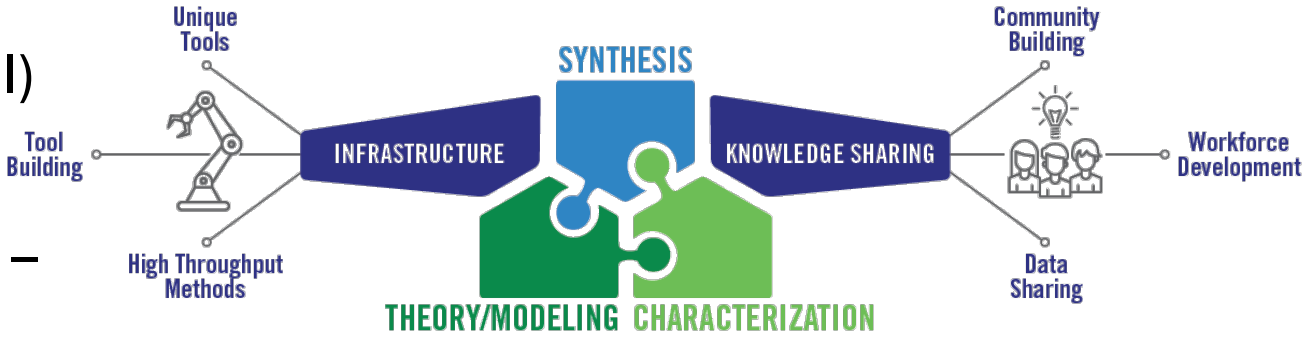
Materials Innovation Platforms (MIP)

- A mid-scale infrastructure program in the Division of Materials Research (DMR):
  - 2 previous competitions in 2015 & 2019
  - The third competition in 2025
- Designed to accelerate advances in materials research & meet national needs
- Use the Materials Genome Initiative (MGI) approach
- Build and nurture a scientific ecosystem – including in-house research scientists, users, and other scientists – sharing knowledge (tools, codes, samples, data and metadata, know-how, …)









MATERIALS INNOVATION PLATFORMS

PARADIM · 2D Crystal Consortium NSF Materials Innovation Platform · BioPACIFIC Materials Innovation Platform · GlycoMIP

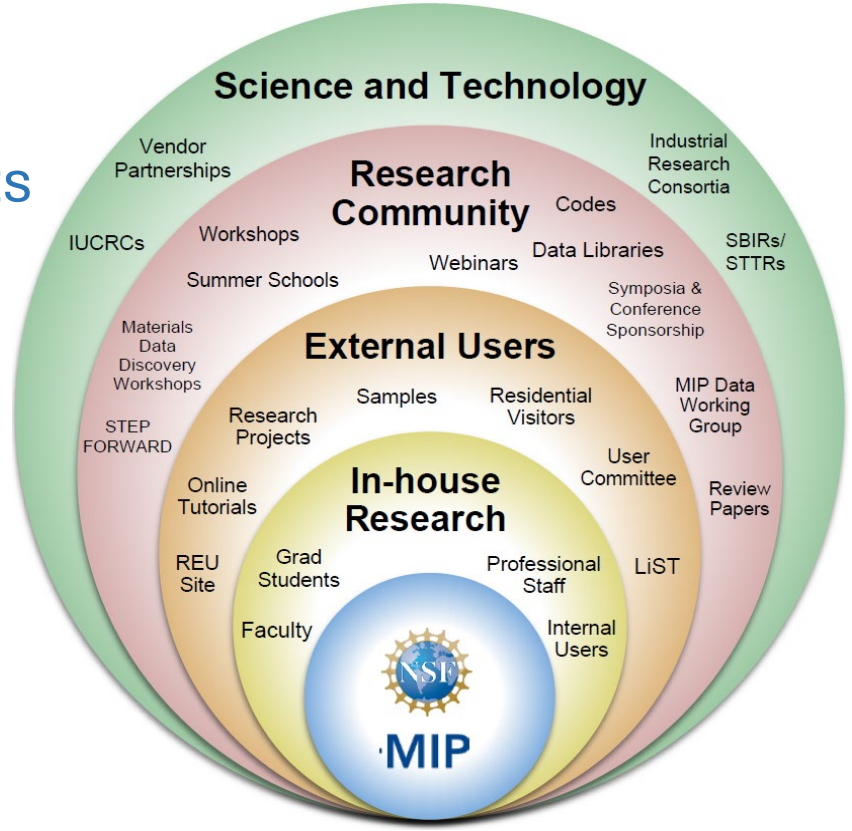
Materials Genome Initiative (MGI)

- The U.S. Government launched MGI in 2011.
- Three major goals of MGI Strategic Plan (https://www.mgi.gov/, 2021):
  - Unify the materials innovation infrastructure
  - Harness the power of materials data
  - Educate, train, and connect the materials research & development workforce
- The MIP program, established in 2015, makes major contributions to each of the three major goals.
- MIPs are driven by the MGI approach with materials synthesis/processing, materials characterization, and theory/modeling/simulation applied iteratively to realize targeted outcomes.
  - The interactive, closed-loop process is required for in-house research and is expected for the user program as a whole, but not required for individual user projects.

4 Pillars of MIP Convergence

MIPs are neither typical research centers nor traditional user facilities.

1. Use an integrated approach to meet the critical needs for research, training, and research infrastructure
2. Foster a culture of knowledge sharing among in-house research scientists, external users, and other scientists
3. Enable iterative, closed-loop efforts across materials synthesis/processing, materials characterization, and theory/modeling/simulation
4. Empower the merging of ideas, approaches and technologies from widely diverse fields of knowledge (domain science fields relevant to MIP, data science, informatics, …)



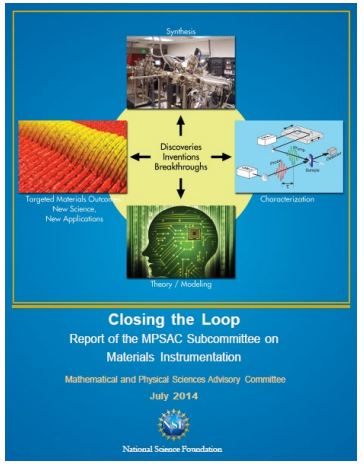
What Does a MIP Do?

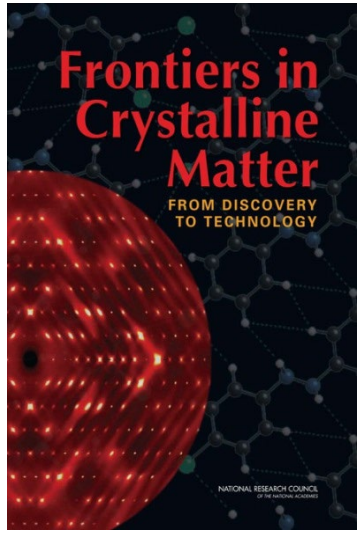
- **Develop** next-generation experimental and computational **tools**, as well as advancing the capabilities of the current state-of-the-art tools
- **Conduct in-house research** by a transdisciplinary team in **a focused topic** designed to address **a grand challenge of fundamental science** and **meet a national need**
- **Operate a user facility** that provides **unique** materials research tools, samples, data, and technical services **open** to a diverse community of external researchers at various institutions
- Serve as an educational focal point for **training** the next generation of tool developers and users

A MIP builds and nurtures **a scientific ecosystem**, which includes in-house research scientists, external users and other scientists who share tools, codes, samples, data, and know-how in order to strengthen collaboration among the scientists and enable them to work together in a new modality.

The First MIP Competition

- When: 2015
- Topic: Bulk and thin-film crystalline hard materials
- Statistics:
  - 42 proposals reviewed in 2 panels
  - 4 finalists invited to reverse site visit at NSF in August 2015
  - 2 awards made in March 2016 (5 years, plus a 5-year renewal based on performance)





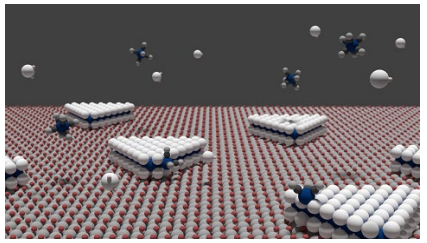
2D Crystal Consortium
NSF Materials Innovation Platform

PARADIM
AN NSF MATERIALS INNOVATION PLATFORM

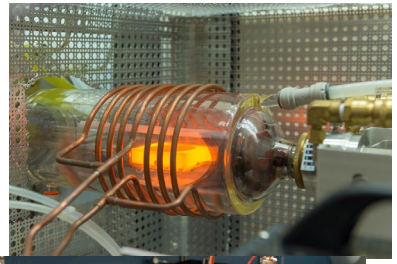
- Both 2DCC-MIP and PARADIM successfully renewed in 2021.

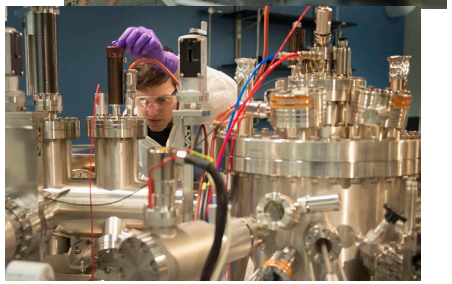
2D Crystal Consortium
NSF Materials Innovation Platform

www.2dccmip.org



- Focus: Layered chalcogenide crystals and related 2D materials
- Major User Facilities (all at Penn State University):
  - Thin-film growth: MOCVD with Raman, photoluminescence & ellipsometry; MBE with STM, SEM & laser ARPES; glovebox cluster tool for 2D layer transfer with metal deposition & AFM (new); and confinement heteroepitaxy (new)
  - Bulk crystal growth: chemical vapor transport furnaces; and double-crucible Bridgman furnace (new)
  - Theory and simulation: growth kinetics, characterization, *etc*.





- Major Activities:
  - Accept user proposals year round
  - Resident Scholar Visitor Program
  - Annual Graphene and Beyond workshops
  - Webinars (all recorded and available online)
  - Data: Lifetime Sample Tracking (LiST), LiST 2.0 with machine learning (new), public data set and instrument DOIs (new), STEPFORWARD

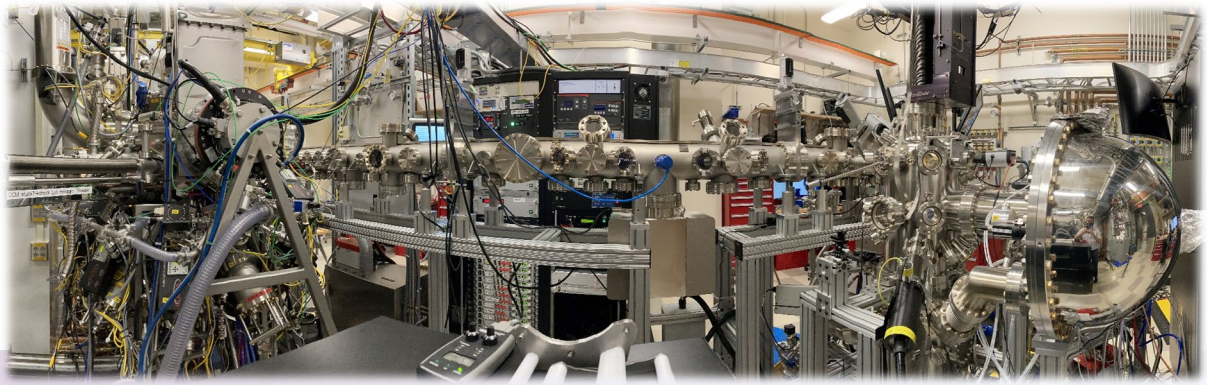
PARADIM
AN NSF MATERIALS INNOVATION PLATFORM

www.paradim.org

- **Focus:** Inorganic single crystals and epitaxial thin films with superior electronic characteristics, particularly interface quantum materials

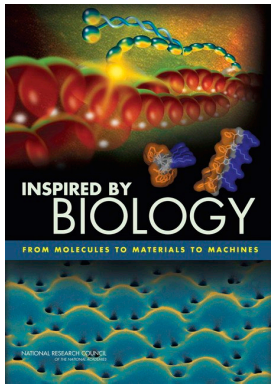
- Major User Facilities (at Cornell University unless otherwise noted):
  - Thin-film growth: MBE (62 elements) with spin-resolved (new) ARPES & laser sample heating (2000°C, new)
  - Transmission Electron Microscopy at world's highest resolution (2nd generation EMPAD)
  - Theory and Simulation: electronic properties and mismatched interface theory
  - Bulk crystal growth (at Johns Hopkins Univ): world's first floating-zone furnace (FZF) with 300-atm O_2, tilted laser-diode FZF, and laser-heated 1000-atm pedestal furnace (new)

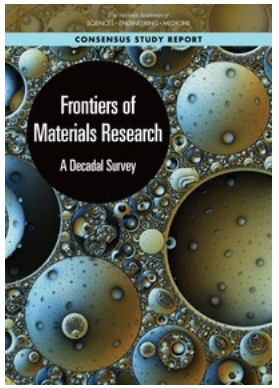
- Major Activities:
  - Accept user proposals year-round
  - Summer schools (all recorded & available online)
  - Public data sets and analysis codes associated with published papers at PARADIM website (new)
  - MIP forum at Fall MRS Meetings (with other MIPs)

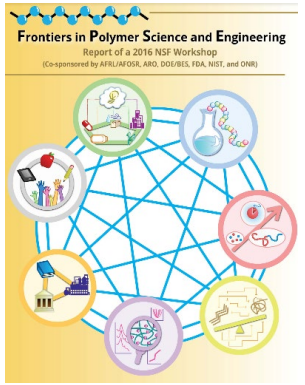


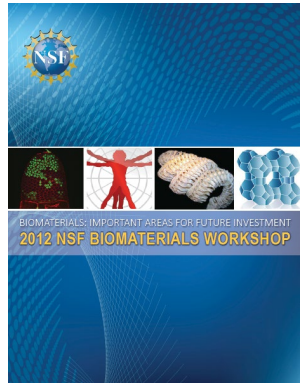
The Second MIP Competition

- When: 2019
- Topic: The convergence of materials research with biological sciences for developing new materials
- Statistics:
  - 27 proposals reviewed in 2 panels in September 2019
  - 4 finalists invited to reverse site visit at NSF in November 2019
  - 2 awards made in August 2020 (5 years, plus a 5-year renewal based on performance)









BioPACIFIC NSF Materials Innovation Platform DMR-1933487

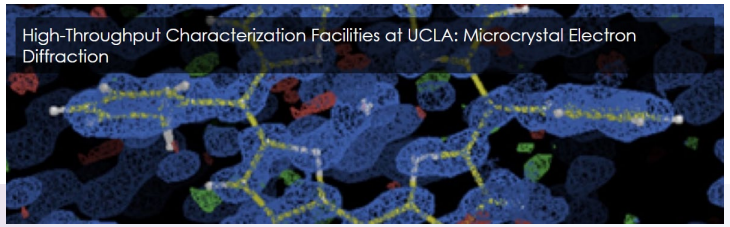
GlycoMIP NSF Materials Innovation Platform

- The renewal proposals of BioPACIFIC MIP and GlycoMIP are being evaluated.

BioPACIFIC
NSF Materials Innovation Platform DMR-1933487

www.biopacificmip.org

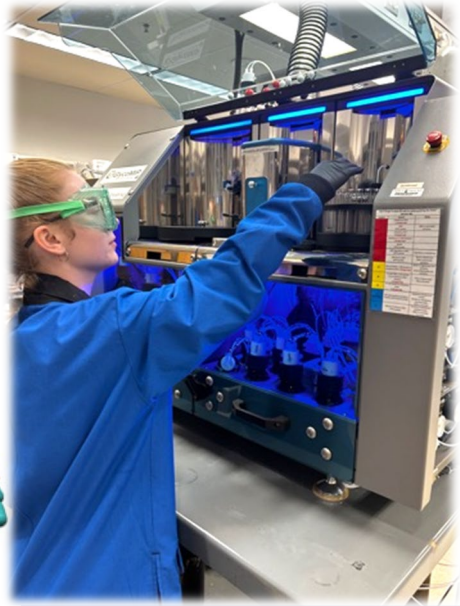
- Focus: Scalable, high-throughput, and data-driven development of advanced bioderived materials
- Major User Facilities: (at UC Santa Barbara and UC Los Angeles)
  - Living Bioreactor: automated gene assembly, amplification, transformation, strain growth, and metabolite analysis (UCLA)
  - Synthetic Chemistry: robotic and solid-phase synthesis, flow chemistry, and 3D printing (UCSB)
  - Characterization: Next-generation x-ray diffraction, micro rheology (UCSB); micro electron diffraction (UCLA)
  - Theory and Simulation: Multiscale biopolymer modeling and simulation-guided learning (UCSB & UCLA)
- Major Activities:
  - Accept user proposals & sample requests year round
  - Summer schools and industry workforce development
  - BioPACIFIC MIP's Digital Ecosystem with open access

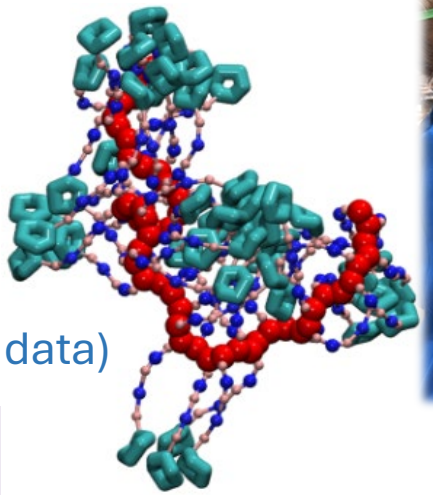


GlycoMIP
NSF Materials Innovation Platform

www.glycomip.org

- Focus: Scalable synthesis, high-throughput characterization, and mesoscale modeling of novel glycomaterials
- Major User Facilities (at Virginia Tech and the University of Georgia):
  - On-demand glycan synthesis: two automated glycan synthesizers
  - *De novo* structure determination: expert services on state-of-the-art spectrometers
  - Biomolecular interaction analysis: high-throughput and automated instrumentation
  - Solution-state 3D structure analysis: Raman and infrared optical activity
  - Theory and simulation: virtual user facility for glycan modeling
- Major Activities:
  - Year-round acceptance of proposals and sample requests
  - Summer schools and hands-on training courses
  - Open-access webinars and educational videos
  - Open-access databases (spectra, molecular models, synthesizer data)





The Third MIP Competition - Topic

- "Complexity offers a second ripe direction for both soft and hard materials synthesis. The best understood materials are the simplest, where structure, composition and purity can be controlled reliably to produce targeted science or technology outcomes. Increased complexity, however, is a basic requirement for increased functionality." – From "*Closing the Loop: Materials Instrumentation*"

  https://www.nsf.gov/mps/advisory/mpsac_other_reports/subcommittee_report_mi_final.pdf

- Topic: A set of complex materials: alloys, amorphous, and composite materials
  - A proposal on alloys, amorphous, and/or composite materials will be considered.
  - A competitive proposal needs to articulate its plan of and anticipated impacts on advancing research of alloys, amorphous, and/or composite materials as complex materials.
  - A proposal mainly on biomaterials and polymer research will not be considered in the third MIP competition because the second MIP competition in 2019 included an emphasis on these topics.

Eligibility and Limitations

- Proposals may only be submitted by Institutions of Higher Education (IHEs) accredited in and having a campus located in the U.S.
  - The 2 institutions that were awarded a MIP in the 2019 competition as the lead institution are not eligible to submit a MIP proposal as a lead institution in the 2025 competition.
  - An institution that submits a proposal is expected to have extensive materials research capabilities so that it is in a strong position to engage external users and build a scientific ecosystem.
- One MIP proposal per organization as the lead institution
  - Only the single proposal method, submitted by the lead institution with sub-awards to other institutions if any, should be used.
- Each proposal must be directed by a team of at least 3 Senior/Key Personnel.
- Individuals may be designated as Senior/Key Personnel (Principal Investigator/Project Director, co-PI, and other faculty or equivalent) on only one MIP proposal.

The Third MIP Competition - Major Changes

- Budget and duration – three phases:
  - Phase 1: $18M - $30M over 6 year – MIP proposals to be submitted in May 2025 are for phase 1.
  - Future Phase 2: MIP program's funding may be continued for 4 additional years, based on a rigorous and favorable review
  - Future Phase 3: For a MIP with a credible long-term plan, the MIP program may provide support at a reduced level for a maximum of 2 years to allow the MIP to have a smooth transition from a mode of primary funding from the MIP program to multiple funding sources.
- Clarify user fee: While MIPs do not charge academic users in the U.S. for reasonable time with experts, technicians, or use of equipment acquired through the MIP award, users may be charged for:
  - extended use of time of the MIP equipment
  - use of MIP equipment with similar equipment readily available at other universities in the U.S.
  - use of non-MIP equipment at the institution that hosts a MIP
  - non-routine and/or expensive consumables and supplies
- Each MIP needs a Managing Director and a User Facility Coordinator.

Budget Guidance

- $18M - $30M over 6 years
  - Annual budgets should not be evenly distributed over 6 years.
  - Instrument acquisition and development are expected to be mainly in the first few years.
  - A ramp-up period is expected for other budget items.
- 3 MIP activities likely having the highest budget
  - Instrument acquisition and development (mainly in the first few years)
  - User facility operation
    - Begin in year 2, ramp up over time, and reach a steady state by year 4
    - No less than the in-house research budget after reaching the steady state
  - In-house research (with a ramp-up period)
- Knowledge sharing is critically important even though its budget may be smaller than that for the 3 activities above.

Competition Timeline

- 5:00 PM local time on May 15, 2025: Proposal submission deadline
  - Project description is limited to 40 pages.
- May 16, 2025: Email an Excel file that lists all Senior/Key Personnel to mip@nsf.gov
- August 2025 (tentative): Invitation of finalists for reverse site visit at NSF
- Fall 2025: Reverse site visit at NSF
- May 2026 (tentative): Award
- Fall 2025 – spring 2026: Declination

Review Criteria

- Intellectual Merit
- Broader Impacts
- Additional MIP-solicitation-specific review criteria, each linking to a section in the Project Description of an MIP proposal
  - Vision/Motivation
  - Knowledge Sharing
  - In-House Research
  - Infrastructure
  - User Facility Operation
  - Training
  - Broadening Participation
  - Collaboration with industry, national laboratories, and others
  - Management – to be evaluated during the reverse site visit

Additional Review Criterion: Vision/Motivation

The text of the review criterion:

- How well is the proposal motivated by addressing **a grand challenge or challenges** of **fundamental science** aligned with **national priorities**?
- To what extent will the vision, if realized, have a transformative impact?

Additional consideration:

- Consider what a MIP can do for addressing a scientific grand challenge or challenges, not simply what one can do for career advancement
- Consider what a MIP can do for benefiting the whole nation, not just a university or several universities within a region in the US
- Consider the scientific impacts in the national and international context

Additional Review Criterion: Knowledge Sharing

- To what extent will the proposed MIP substantially accelerate materials discovery and development beyond current approaches, through **sharing of knowledge (tools, codes, samples, data and know-how)**?
- How **effective** will the knowledge sharing mechanisms likely be?
- Does the MIP have a sound plan to take advantage of opportunities that the emerging data science provides?
  - MIP builds and nurtures a scientific ecosystem.
  - MIP goes beyond data management and sharing – It shares tools, codes, samples, data (including meta-data), and know-how.
  - Different sharing mechanisms could be needed depending on (i) what is shared and (ii) with whom (in-house research scientists; users; other scientists) knowledge is shared.
  - MIP makes full use of opportunities provided by data science such as artificial intelligence and machine learning.

Additional Review Criterion: In-House Research

- How well is the proposed in-house research **focused and targeted** to **addressing a critical scientific challenge**?
- How well does the proposed research use **a tightly closed collaborative loop process** with accelerated, iterative feedback among materials synthesis/ processing, materials characterization, and theory/modeling/simulation?

  - The in-house research scope should be focused, smaller than the scope of the whole MIP.
  - The in-house research is synergistic to the user program.
  - The in-house research is required to use the Materials Genome Initiative (MGI) approach and needs expertise of materials synthesis/processing, characterization, and theory/modeling/simulation.
  - If more than one institution is involved in the in-house research, effective mechanisms to prevent the negative impact of distance on the collaborative, interactive "closed loop" nature of the MIP must be clearly described.

Additional Review Criterion: Infrastructure

- To what extent does the proposed MIP meet **a critical infrastructure need** for the materials community?
- What is the degree of **uniqueness** of the proposed key instruments for materials synthesis/processing and materials characterization in the national context?
- Do the proposed instruments enable **new ways of synthesis/processing** of complex materials?
- Are the **plans and timelines** for equipment acquisition, development, and commissioning well thought out?
- For tool development, does the proposal have a comprehensive and realistic **analysis of risks** and a sound mechanism to **address the risks**?

  - MIP's infrastructure is to meet critical research needs in the US.
  - Consider both new tools acquired/developed through a MIP award and existing tools on campus
  - (to be continued)

Additional Review Criterion: Infrastructure (continued)

- MIPs are expected to offer state-of-the-art materials synthesis/processing tools.
- Advancement in characterization methodologies and theory/modeling/simulation approaches that benefit the research endeavor is also expected.
- While all instruments needed for world-class research facilities will be considered, a high priority for the MIP Program is to support instruments with unique capabilities.
  - Acquisition of instruments readily available at universities in U.S. is a lower priority.
- In addition, MIPs are expected to be at the forefront of the intelligent deployment of artificial intelligence/machine learning (AI/ML) techniques and the implementation of autonomous experimentation.
  - Acquisition and development of fully or partially autonomous equipment, as well as developing autonomous workflow, is highly encouraged.
  - However, this solicitation does not limit the requested equipment to autonomous ones.
- If instruments are located at more than one institution, effective mechanisms to minimize the negative impact of distance on user service must be clearly described.

Additional Review Criterion: User Facility Operation

- How well-conceived are the plans for the user facility operation (*e.g.*, access modes, user proposal review and selection process, staffing, instrument time/resource allocation, user training, and safety)?

  - Need expertise and sound plans for various aspects of user facility operation
  - For instruments acquired through the MIP award:
    - At least 50% of the instrument operation time is for external users, which are defined as those who are neither MIP Senior/Key Personnel (and members in their research groups) nor affiliated with the institutions where MIP user facilities are located.
    - MIP are also expected to reach users from a broad range of academic institutions in the U.S.

Additional Review Criterion: Training

- To what extent will the proposed platform serve as an educational focal point for training the next generation of **instrument developers** and **users**?

  - Engage in small number of well-chosen training and outreach activities
    - Training of users, especially external users – This must be the top priority of the proposed training activities.
    - Training of next generation of instrument developers
    - Outreach to potential users

Additional Review Criterion: Broadening Participation

- To what extent is the plan strategic and likely to meet the stated goals for participation by a diverse group of users and from a broad range of academic institutions in the United States?

  - Demonstrate a significant commitment to the involvement of the full spectrum of diverse talent that society has to offer
    - Include members of groups from underrepresented and under-served communities, as MIP participants and as users.
    - Reach users from a broad range of academic institutions in U.S.

Additional Review Criterion: Collaboration with Industry, National Laboratories, and Others

- To what extent does the proposal include industrial involvement through, for example, sharing instruments, samples and expertise, for commercialization of new instruments; preparation of future innovation and entrepreneurship leaders; and deployment of novel materials?

  - MIPs are encouraged to make progress towards translation, which may include the generation of new intellectual property, creation of new or broader collaboration with industry, licensing of NSF-funded research, creation of new technology and/or processes adopted by the public and/or philanthropic sector, and the training of future innovation and entrepreneurship leaders.

Additional Review Criterion: Management

- Are the proposed roles of key leadership positions and major committees appropriate?
- Are the proposed MIP operation procedures appropriate?

  - Each MIP needs a Managing Director and a User Facility Coordinator.
  - Potential members of an External Advisory Committee should neither be approached nor identified in the proposal.
  - Major resources that the organization(s) will provide to the proposed MIP (not given as dollar equivalents):
    - Highlight in section 11 of the Project Description
    - Describe in detail at the section of "Facilities, Equipment and Other Resource"
    - Confirm in official letter(s)

Questions?

- NSF MIP website
  - https://new.nsf.gov/funding/opportunities/mip-materials-innovation-platforms
- MIP website
  - https://mip.org/
- MIP Program Directors at NSF
  - Z. Charles Ying
  - Debasis Majumdar
- Email address of the MIP Program Directors
  - mip@nsf.gov