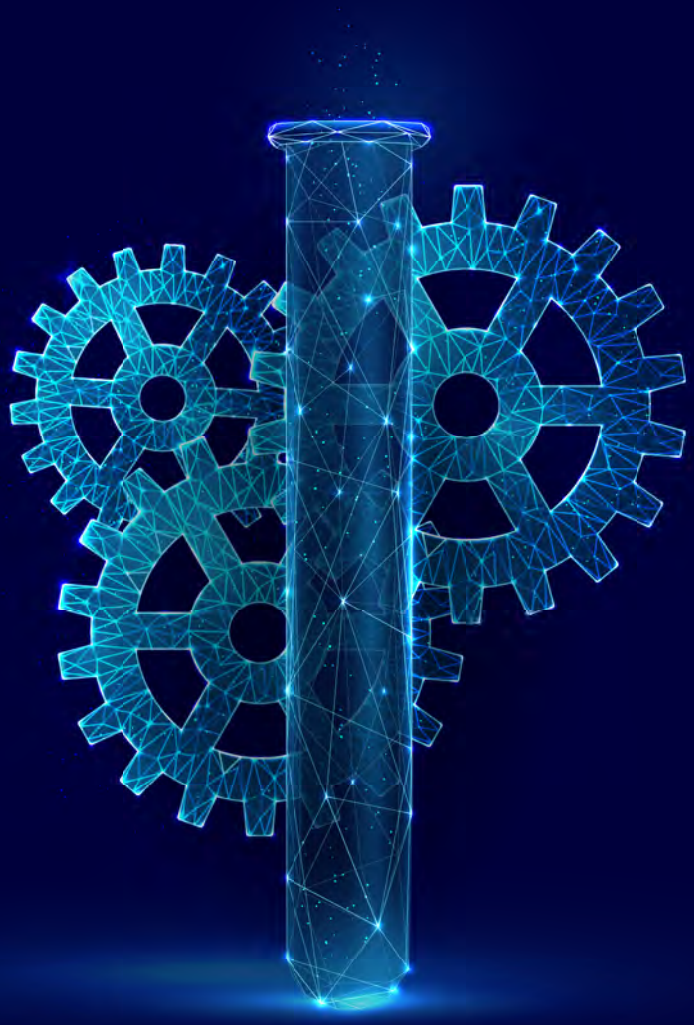
ATP·Bio℠

Public Annual Report
Year One



Our Mission

ATP-Bio's mission is to make transformative discoveries, train a diverse workforce, and connect resources and partnerships to ethically translate technologies for the storage and distribution of living biological systems.

Our Vision

ATP-Bio's vision is to stop biological time, allowing living products to be readily available across the globe to advance healthcare, biodiversity, and food supply and sustainability.

Our Pillars

diversity & culture of inclusion

engineering workforce development

convergent research

innovation ecosystem

ethics & public policy

Contents

Message from the Director

The fundamental premise of the NSF ERC program is that a large, multi-disciplinary, multi-faceted team can make substantial progress on many scientific fronts. I'm very pleased to say that this Annual Report — ATP-Bio's first — shows that we are affirming that vision.

The following pages highlight the Year 1 achievements of ATP-Bio's five pillars: Convergent Research, Diversity and Culture of Inclusion, Engineering Workforce Development, Innovation Ecosystem, and Ethics and Public Policy. I'll let you read the details, but want to point out that none of these pillars stands by itself. Our excellent REU program contributes to our engineering research, for example. Progress in biopreservation accelerates industry involvement – and vice versa. Our conversations about diversity and inclusion and our Ethics and Public Policy Panel meetings are helping scientists think more deeply about how their labs work and about the long-term impacts of their new technologies. Because of its ERC structure, the ATP-Bio team is, indeed, making significant progress on many fronts and doing so in an integrated manner.

I'm also very pleased that Year 1 has laid a fantastic foundation for continued progress across our pillars. In true scientific fashion, this will include breakthroughs that we didn't even imagine a few years ago. I can't wait.

I hope this Annual Report inspires you to become more engaged with ATP-Bio. Both I and the pillar leads welcome your ideas and energy, so please don't hesitate to reach out or even just get on our mailing list. The ATP-Bio team is making the future of biopreservation to move and store living products across the globe, and we want you to be a part of that.

Leadership & Advocacy

Academic institutions

ATP-Bio is a world-class partnership between engineering, medicine, science, education, business, and ethics at five premier research universities. It supports the crucial advancement of biopreservation technologies and enables innovation, commercialization, and diverse workforce development. Across ATP-Bio, the institutional resources are abundant.

University of Minnesota (UMN) is the lead institution as ATP-Bio headquarters. UMN has expertise in heat transfer, nanomedicine, cryobiology, particle technology, aerosols, 3D printing, cell therapies, physiology, bioelectronics, chemistry, advanced manufacturing, STEM education, psychology, bioethics, law and policy, business, innovation and commercialization.

Massachusetts General Hospital (MGH), ATP-Bio's co-lead institution, is a world leader in every facet of cryobiology including biopreservation, biomineralization, biostabilization, microfluidics, tissue engineering, cryopreservation, BioMEMS, chemical engineering, organ reengineering, organ preservation, metabolomics.

University of California-Riverside (UCR) is a Hispanic-Serving Institution (HSI) and one of America's most successful at graduating students from underrepresented and disadvantaged backgrounds. UCR brings expertise in nanofabrication, nanostructures, nanoparticle development, laser technology, and optics.

University of California-Berkeley (UCB) provides pioneers in cryobiology, micro-physiological systems, micro and nano energy conversion, organoids, drug discovery, and thermal measurement technologies.

Carnegie Mellon University (CMU) brings cryobiology, cryosurgery, and cryomedicine research to the Center.

Genesis of ATP-Bio

ATP-Bio by the Numbers

SEPTEMBER 1, 2020 – JUNE 30, 2021

ATP-Bio Personnel

30 Senior Personnel

7 Administrative Staff

15 Research Staff

40 Trainees: Postdocs, Graduate Students, Undergraduate Students

Publications

4 Core Publications (peer-reviewed journals)

25 Associated Publications (peer-reviewed journals)

Formal & Informal Dissemination

14 Workshops, Short Courses, Trainings, Webinars

4 Innovation-Focused Events

13 Conferences, Symposia, Colloquia, Invited Talks

Education & Outreach

10 Research Experiences for Undergraduates (REU) program

18 Pre-College Teacher Professional Development

20 High School Engagement Program (Young Scholars)

Inventorship & Entrepreneurship

2 Inventions Disclosed

1 Provisional Patent Application Filed

Societal Benefits

ATP-Bio is a visionary engineering research center leading the field of biopreservation and developing a diverse and inclusive STEM workforce to continue to drive this important field. ATP-Bio's vision is to accelerate technologies that enable widespread preservation and distribution of cells, microphysiological systems, tissues and organs, and whole organisms. These advancements will eliminate barriers that currently prevent biological systems from providing massive societal benefit through the biomedical, aquaculture, and several other global industries.

ATP-Bio will accomplish this through three focused areas of research:

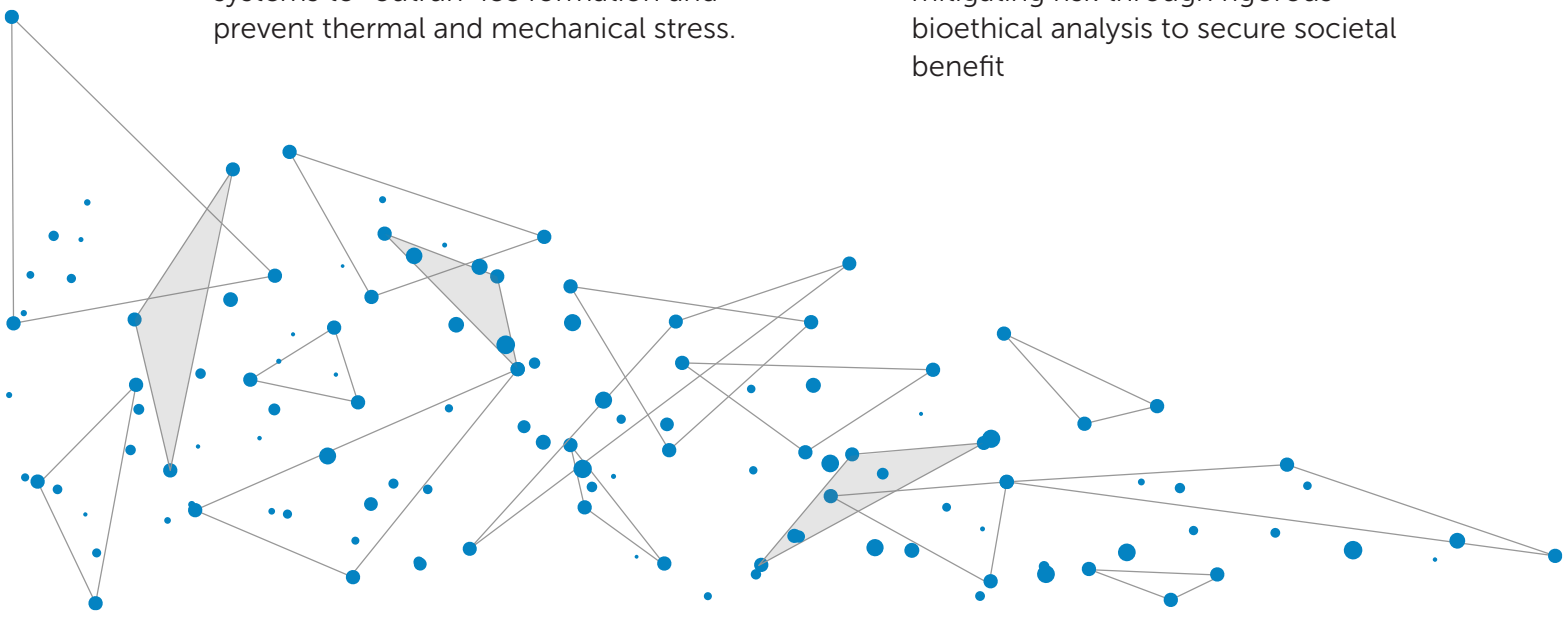
- **Thrust 1, Biological Engineering:** Better prepare biological systems for subzero preservation and recovery to normal function
- **Thrust 2, Multiscale Thermodyanamics of Water:** Prevent and mitigate ice crystallization during the cooling process.
- **Thrust 3, Rapid and Uniform Warming:** Rapidly and uniformly rewarm biological systems to "outrun" ice formation and prevent thermal and mechanical stress.

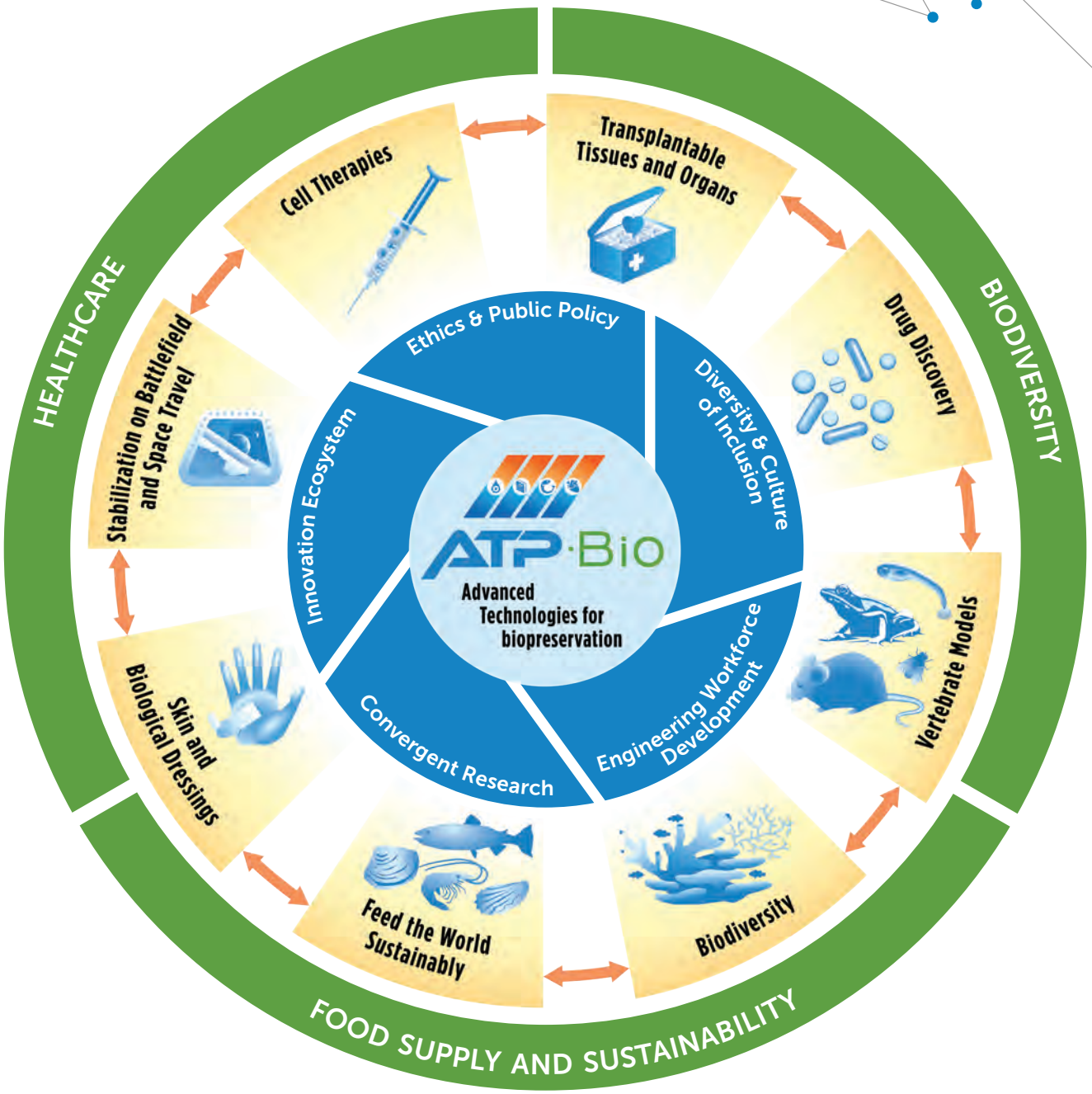
At each stage, convergent engineering research will aim to:

- eliminate or control ice
- mitigate toxicity from cryoprotective agents
- eliminate thermal and mechanical stress

Through transformative biopreservation technology, ATP-Bio is:

- building the biopreservation workforce and developing a culture that fosters an inclusive STEM workforce
- using STEM education research and best practices to develop programs, curriculum, and experiences that reach diverse groups of people
- incorporating the ecosystem's priorities through our scientific and industry advisory boards
- commercializing and translating technologies to revolutionize cell therapy, regenerative medicine, aquaculture, and organ & tissue markets
- mitigating risk through rigorous bioethical analysis to secure societal benefit




HEALTHCARE
BIODIVERSITY
FOOD SUPPLY AND SUSTAINABILITY
Cell Therapies
Transplantable Tissues and Organs
Drug Discovery
Vertebrate Models
Biodiversity
Feed the World Sustainably
Skin and Biological Dressings
Stabilization on Battlefield and Space Travel
Ethics & Public Policy
Diversity & Culture of Inclusion
Engineering Workforce Development
Convergent Research
Innovation Ecosystem
ATP·Bio
Advanced Technologies for biopreservation

PILLAR

Diversity & Culture of Inclusion

DCI

ATP-Bio aims to broaden participation from groups that historically have been underrepresented in STEM so that we increase the potential for impact and innovation. Although there are many ways that such increased diversity can be understood, our primary focus is on broadening participation with respect to race, ethnicity, gender, disability, socioeconomic status, veterans, and first-generation students.

We aim to promote diversity and inclusion across all ATP-Bio institutions and across all levels of the Center, including leadership, faculty, staff, trainees, students, industry partners, and other stakeholders.

We aim to build and sustain a culture of inclusion in which all members feel valued and welcomed, can contribute creatively, and can gain respect and mutual benefit from participating. This includes intentional accessibility practices that ensure facility, technology, and activity access for individuals with a wide range of disabilities.

Year One Highlights

- Completed the ATP-Bio Code of Conduct and Statement of Diversity and Inclusion with contributions from Center leadership, Senior Personnel, and the SLC. This document 1) sets expectations for behavior during ATP-Bio meetings and member interactions, and 2) clearly articulates the Center's commitment to diversity, equity, and inclusion.
- Developed a six-week inclusive mentoring education series in collaboration with EWD leaders. This series, which took place over the summer, both helps Center members apply DEI principles to their scientific work and prepares future scientists and engineers to be inclusive mentors and leaders.
- Created an online repository of DCI tools and resources. The repository provides information about promoting diversity and inclusion and a platform for sharing new DCI-related materials and ideas.

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Engineering Workforce Development

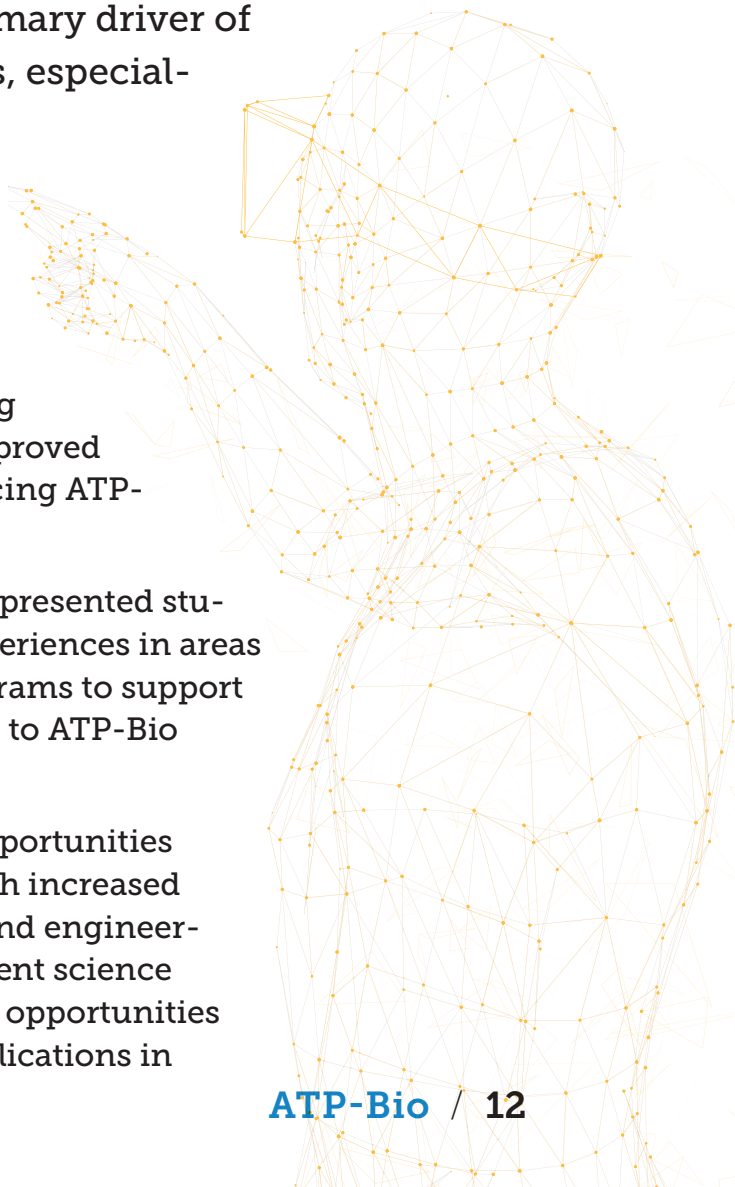
EWD

Cell therapy, regenerative medicine, aquaculture, and organ and tissue markets are estimated to be between $300B–600B (US-World) and are predicted to grow substantially by 2025, making workforce development a critically important part of ATP-Bio.

ATP-Bio aims to improve the quantity and quality of engineering intellectual capacity, diversifying the workforce to be representative of U.S. demographics by using inspiration from ATP-Bio's science and engineering. "STEM identity" is a primary driver of sustained pursuit in the STEM disciplines, especially for those underrepresented in STEM.

We aim to do this sequentially through:

- Strategic partnerships with diverse middle and high schools to increased integration of engineering into middle and high school science classrooms using culturally responsive approaches and improved STEM identities for all students experiencing ATP-Bio activities.
- Supporting the perseverance of under-represented students in STEM by providing research experiences in areas relevant to ATP-Bio and by creating programs to support community college students transferring to ATP-Bio institutions.
- Providing cross-institutional learning opportunities for ATP-Bio students and trainees through increased knowledge of ATP-Bio relevant science and engineering principles, opportunities for convergent science and cross-institutional partnerships, and opportunities to understand impact on society and applications in industry.



Year One Highlights

- Launched the inaugural ATP-Bio Research Experiences for Undergraduates (REU) Program, which is held for ten weeks over the summer. Ten students from around the country participated in programs at UMN (virtually) and MGH (in-person). The program included a popular Professional Development Webinar Series hosted by ATP-Bio faculty, postdocs, and graduate students.
- Initiated a summer high school internship program in collaboration with St. Paul Public Schools (SPPS) and the SciSparks Outreach program in the UMN College of Biological Sciences. In this six-week program, students engaged in an experiment using a take-home kit related to a biotechnology topic. Participants met with an ATP-Bio Student Leadership Council (SLC) graduate student to discuss their research and discuss how to get into a STEM field.
- Hosted a teacher professional development workshop for SPPS teachers, focusing on the integration of engineering into middle and high school classrooms to support teachers implementing the new Minnesota State Science Standards. In addition, SPPS requested a focus on supporting engineering design for English Language (EL) students. Eleven middle and high school teachers attended the workshop in June and continued to work on curriculum development throughout the summer.

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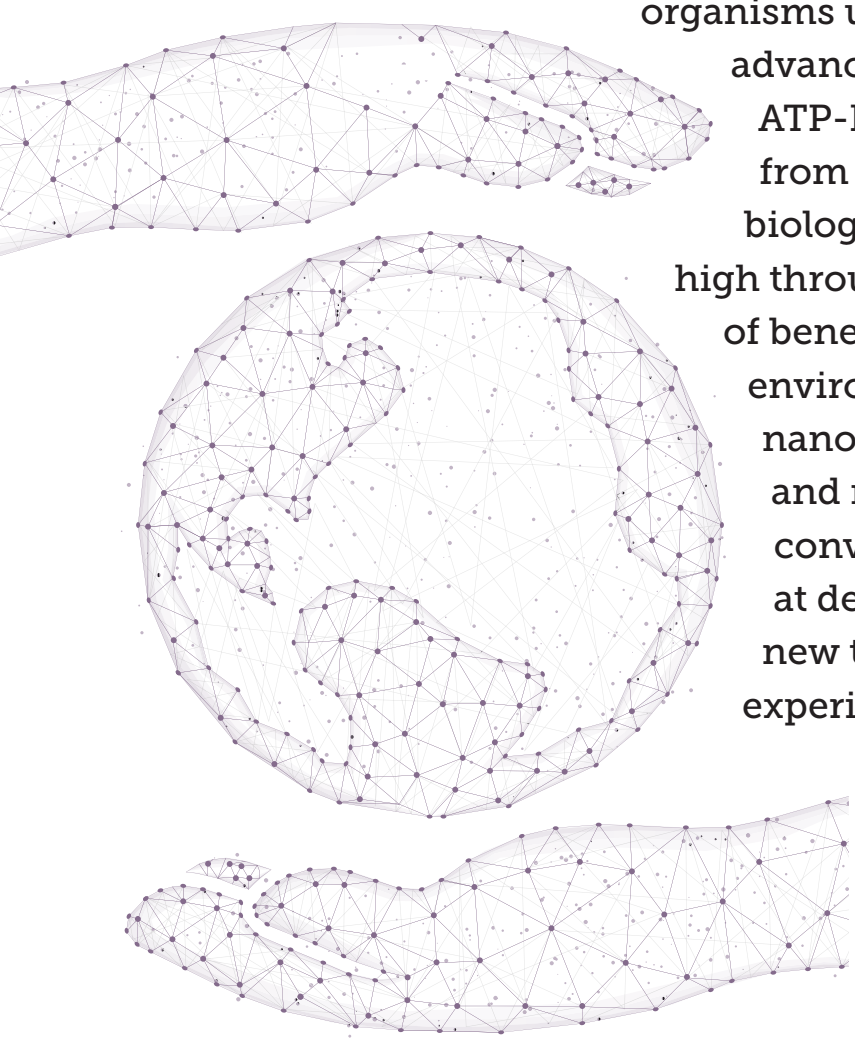
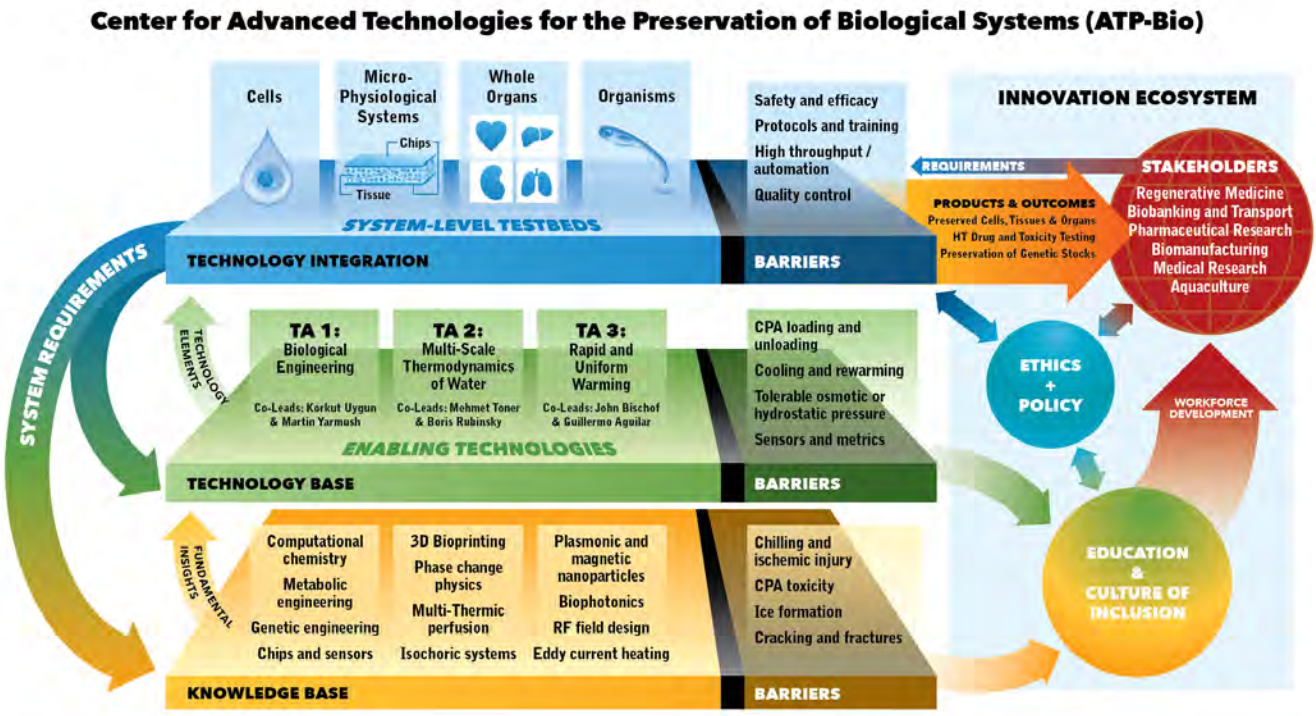
Convergent Research & Engineering

CR

ATP-Bio aims to "stop biological time" and radically extend the ability to bank and transport cells, micro-physiological systems (MPS or "organs-on-a-chip"), aquatic embryos, tissue, skin, whole organs, and even whole organisms using a team approach to build advanced preservation technologies. ATP-Bio envisions a world a decade from now in which a vast range of biological systems are preserved in a high throughput manner for a wide range of benefits to humankind and the natural environment, along with advances in nanotechnology, 3D printing, genetics, and numerous other fields. The convergent research of ATP-Bio aims at developing foundational knowledge, new technologies, and testbed-level experimentation. Our research thrusts use enabling technologies to tackle barriers of ice formation, CPA toxicity, and thermal and mechanical stress.





Year One Highlights

- Developed a protocol for 72-hour supercooled isochoric preservation of autonomously beating engineered 3D human cardiac tissue that retained sarcomere integrity and alignment and had minimal post-preservation differences in beat rate and action potential duration.
- Stored whole rodent livers in a partially frozen state at -15°C for 5 days. These livers remained statistically similar to a transplantable control kidney in vascular resistance, portal lactate, and adenylate energy charge.
- Vitrified rat kidneys and hearts loaded with nanoparticle-containing CPA solutions, then nanowarmed successfully—i.e. without ice crystallization or cracking.

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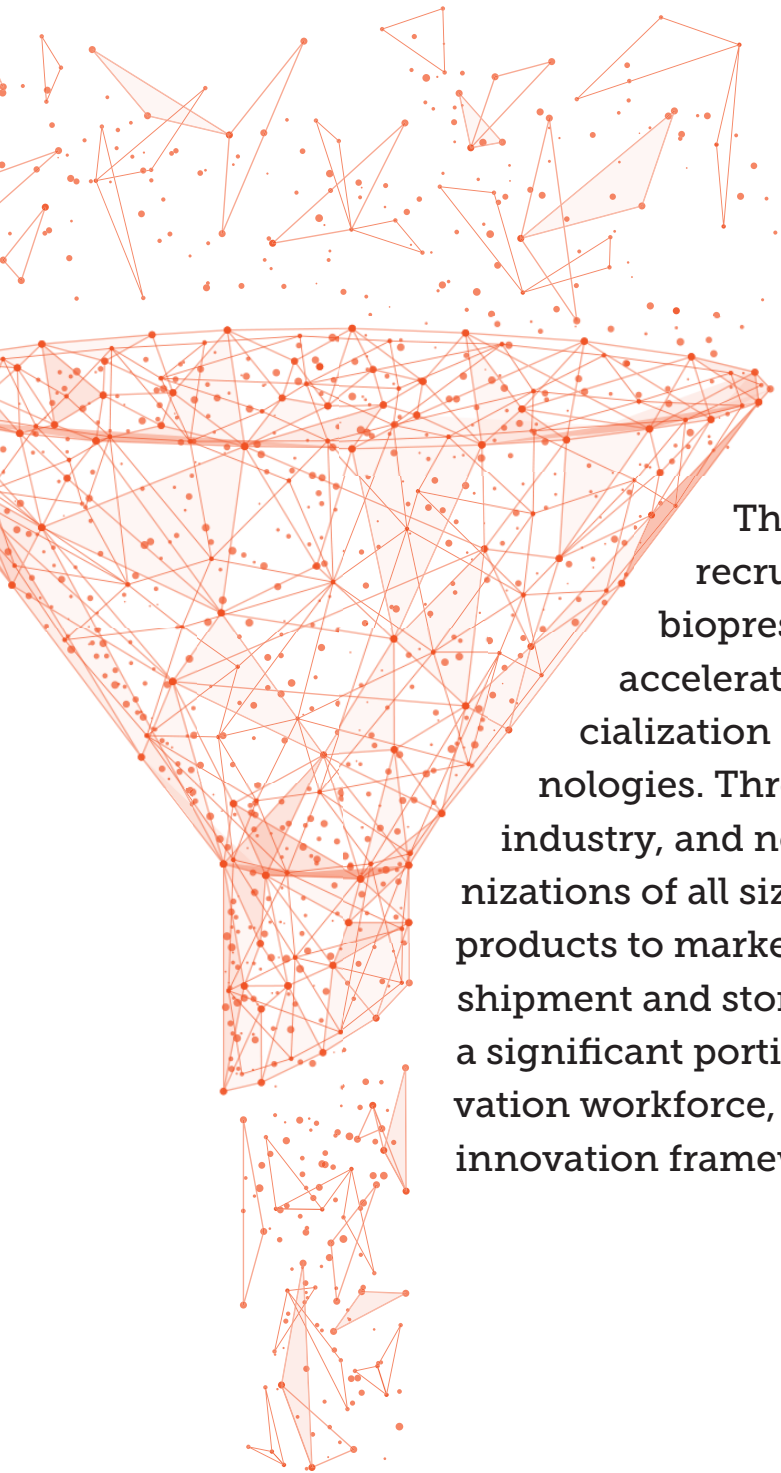
Innovation Ecosystem

IE



ATP-Bio technologies will play key roles in at least four major markets: Solid Organs & Tissues, Aquaculture, Regenerative Medicine & Cell Therapies, and Micro-Physiological Systems (MPS, or "organs-on-a-chip"). Solid Organs & Tissues and Aquaculture markets are larger and thus ripe for disruption from new biopreservation technologies coming out of ATP-Bio. Regenerative Medicine & Cell Therapies and MPS are emerging markets with huge growth potential that can be driven by ATP-Bio innovations.

The Innovation Ecosystem's goal is to recruit ATP-Bio stakeholders across the biopreservation value chain to support and accelerate the development and commercialization of advanced biopreservation technologies. Through this consortium of academic, industry, and non-profit/government entities, organizations of all sizes will be able to bring their living products to market, no longer bound by severe limits on shipment and storage. In addition, we aim to produce a significant portion of the next-generation biopreservation workforce, all grounded in entrepreneurial and innovation frameworks, in both industry and academia.

Year One Highlights

- Developed and implemented an ATP-Bio membership program and created two additional membership categories (Non-Profit/Government and Innovation) to better engage and manage non-profit, government, and other non-industry stakeholders.

  ATP-Bio currently has 18 industry, non-profit, government, and innovation members.

  ### INDUSTRY

  Sustaining Members: AMF Lifesystems, Instant Systems, Nevada Donor Network, Thermo Fisher Scientific

  Full Members: American Type Culture Collection (ATCC), Boston Scientific

  Associate Members: OmniLife, PanTHERA CryoSolutions, Recombinetics, Sylvatica Biotech, Tissue Testing Technologies (T3)

  ### NON-PROFIT/GOVERNMENT

  Isthmus Foundation, LifeGift, MN Sea Grant, Organ Preservation Alliance, Smithsonian Institute, Society for Cryobiology

  ### INNOVATION

  gener8tor

- ATP-Bio disclosed three inventions (two at MGH and one at UMN); one has a pending patent and the other two are under evaluation. UMN also issued an open license for laser nanowarming aquatic systems for non-commercial research and applications.

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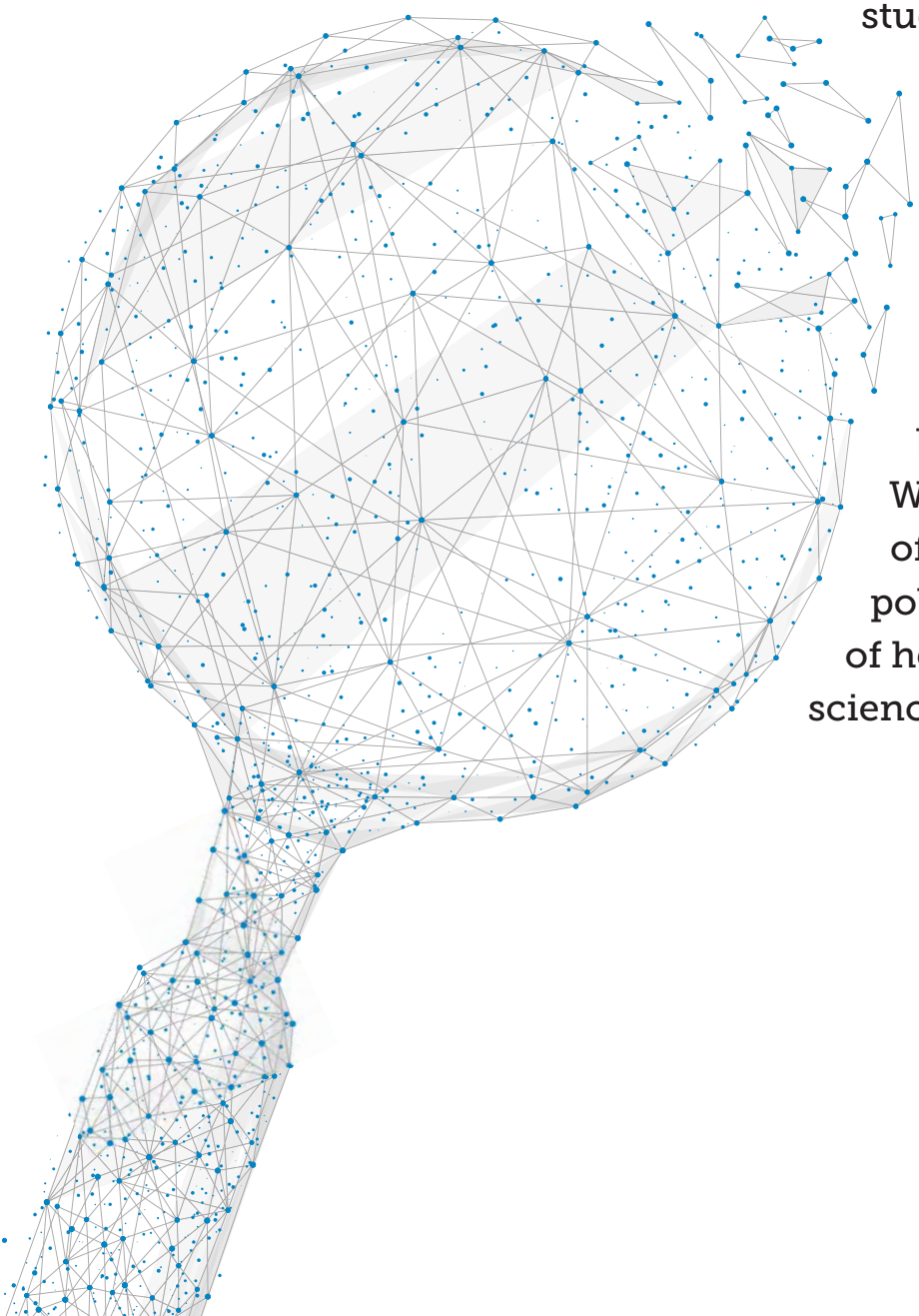
Ethics & Public Policy

EPP

ATP-Bio's Ethics and Public Policy (EPP) Pillar aims to analyze and guide ATP-Bio research and development to manage risk and secure the significant societal benefits of the Center's current and future biopreservation technologies. EPP also envisions ATP-Bio (and future biopreservation) researchers, students, and collaborators as professionals who are aware of the many ethical and public policy issues that their research touches and who can build on EPP's work to continue to responsibly bring societal benefit through biopreservation technology. We envision ATP-Bio as a source of compelling ethics and public policy discussions in the fields of health, environment, and life sciences.



Highlights

- Recruited a stellar roster of top national experts on analysis of emerging technologies for the Ethics & Public Policy Panel (EP3).
- Welcomed ATP-Bio as the 21st member center in the University of Minnesota's Consortium on Law and Values in Health, Environment & the Life Sciences, a leading consortium for NSF- and NIH-funded research on emerging technologies.
- Launched analysis of ATP-Bio research and envisioned applications of ATP-Bio technology, including technology impacting human health and technology targeted to ecosystems and other nonhuman applications.

Get Involved

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