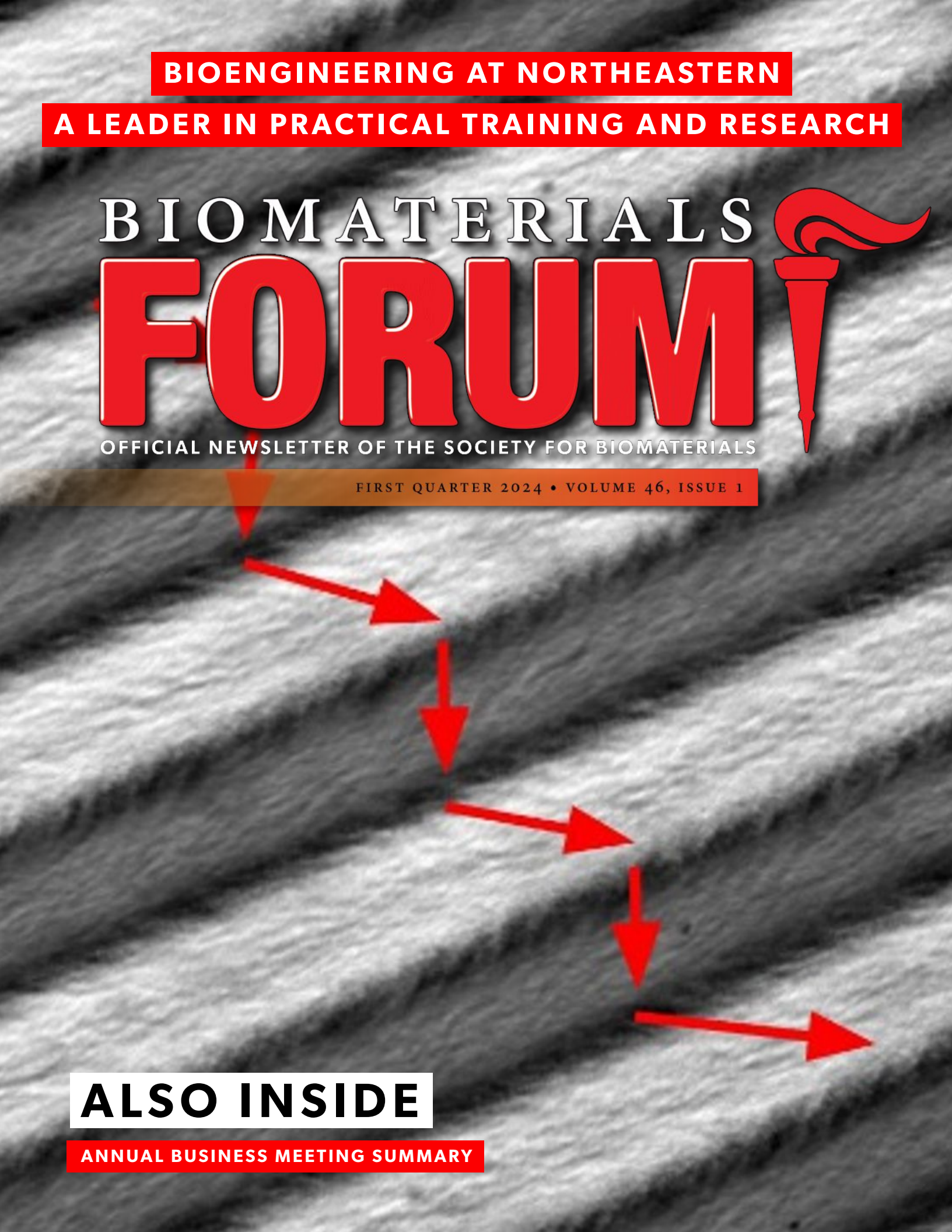
BIOENGINEERING AT NORTHEASTERN

A LEADER IN PRACTICAL TRAINING AND RESEARCH

BIOMATERIALS FORUM

OFFICIAL NEWSLETTER OF THE SOCIETY FOR BIOMATERIALS

FIRST QUARTER 2024 • VOLUME 46, ISSUE 1



ALSO INSIDE

ANNUAL BUSINESS MEETING SUMMARY

Biomaterials Forum, the official news magazine of the Society For Biomaterials, is published quarterly to serve the biomaterials community. Society members receive *Biomaterials Forum* as a benefit of membership. Non-members may subscribe to the magazine at the annual rate of $48. For subscription information or membership inquiries, contact the Membership Department at the Society office (email: info@biomaterials.org) or visit the Society's website, biomaterials.org.

Editorial contributions to *Biomaterials Forum* are always welcome. Contributions should be sent to the Executive Editor and are subject to the terms and conditions of the Editorial and Publication Release. Authors should refer to the Author Guidelines, which are available on the Society's website, when writing submissions. The publisher accepts no responsibility for return or safety of artwork, photographs or manuscripts. Submission of editorial content does not guarantee acceptance or publication.

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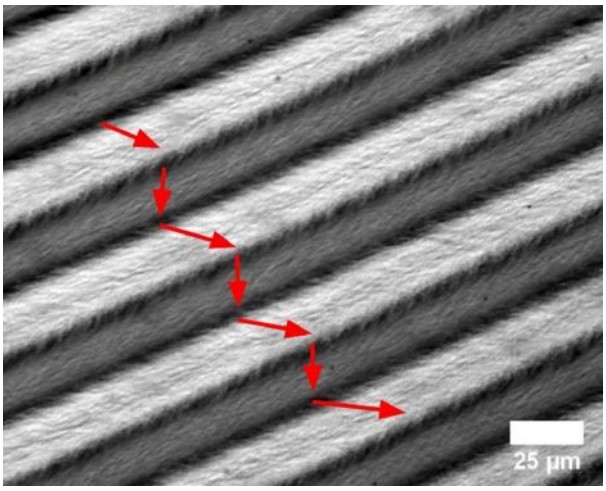
BIOMATERIALS FORUM

The official news magazine of the **SOCIETY FOR BIOMATERIALS** • Volume 46, Issue 1

SPECIAL INTEREST GROUP REPORTERS

BioInterfaces	TBD
Biomaterials & Medical Products Commercialization	Subramanian Gunasekaran • guna@encoll.com
Biomaterials Education	Jeremy Mercuri • jmercur@g.clemson.edu
Biomaterial-Tissue Interaction	Patrick L. McGee • patrickmcgee.dds@outlook.com
Cardiovascular Biomaterials	Astha Khanna • akhanna@gravertech.com
Dental/Craniofacial Biomaterials	TBD
Drug Delivery	Eun Ji Chung • eunchung@usc.edu
Engineering Cells & Their Microenvironments	Silviya Zustiak • silviya.zustiak@slu.edu
Immune Engineering	Yaoying Wu • yw195@duke.edu
Nanomaterials	Mahboubeh Nabavinia • NABAVINIAM20@ecu.edu
Ophthalmic Biomaterials	Frances Lasowski • lasowsfj@mcmaster.ca
Orthopaedic Biomaterials	Roche C. de Guzman • roche.c.deguzman@hosftra.edu
Surface Characterization & Modifications	TBD
Tissue Engineering	Jessica M. Gluck • jmgluck@ncsu.edu

If interested in filling a vacancy above, please reach out to your SIG Chair.
Contact information can be found on individual SIG pages as found **here**.



ON THE COVER

That is a polarization image of pure collagen that crimps on its own if you rattle it down to its lowest energy state. It is also the biomaterial behind BrilliantStrings Mechanotherapeutic technology.

Contents

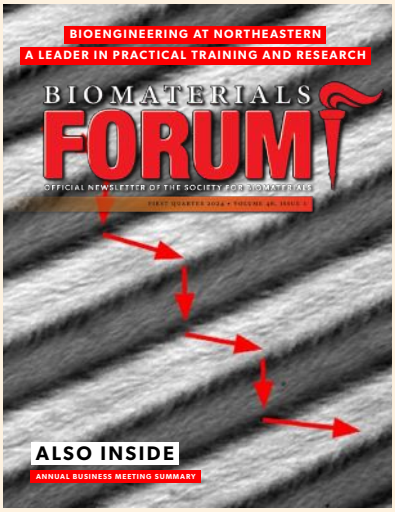
From the Editor

By Roger Narayan, MD, PhD, Biomaterials Forum Executive Editor

Welcome to the current issue of Biomaterials Forum! Professor Sarah E. Stabenfeldt shares the president's letter, which highlights the activities of society members at the World Biomaterials Congress and the activities that will take place at the upcoming Regional Meetings. In addition, the letter mentions the upcoming virtual workshop on Artificial intelligence for Biomaterials Design, which is in conjunction with the Materials Research Society, and plans for the 2025 Annual Meeting. The member news section highlights recent achievements by Natalie Artzi, Binata Joddar, Aijun Wang, and Ho-Wook Jun. The election of Joyce Wong as 2024-2025 President-Elect and Kyle Lampe as 2024-2025 Member-At-Large to the SFB Board of Directors during the 2024 World Biomaterials Congress was also highlighted. This issue contains a feature on bioengineering at Northeastern by Ambika Bajpayee and Abraham Joy, which celebrates the department's 10th anniversary. This article highlights efforts in collagen mechanochemistry by Prof. Jeffrey Ruberti, 3D bioprinting of vasculature by Prof. Guohao Dai, and bio-electroceuticals by Prof. Ambika Bajpayee. Carl Simon provides an update on per- and polyfluoroalkyl substances (PFAS) related to the "Roundtable on PFAS For Medical Device Industry," which was held by the American Institute of Medical and Biological Engineering (AIMBE) Industry Council earlier this year.

I want to thank the society members, staff, and volunteer leaders for their support in preparing this issue. As always, please do not hesitate to contact me at roger_narayan@ncsu.edu if you have news and other information for inclusion in *Biomaterials Forum*.

CALL FOR COVER ART



WE WANT TO FEATURE YOUR EXCITING BIOMATERIALS ARTWORK ON THE COVER OF *BIOMATERIALS FORUM!*

Deadline: Accepted on a rolling basis.

Instructions: Please email artwork (digital images, artistic creations, etc.) to info@biomaterials.org, to the attention of the Executive Editor of the *Biomaterials Forum*. All artwork with biomaterials relevance that have not appeared as a *Forum* cover are welcome. Multiple submissions are permissible.

Description: Selected artwork will appear as the cover of a future issue of *Biomaterials Forum* along with a brief "On the Cover" description of the subject and name/affiliation of the creator.

Format: High-resolution electronic version in .gif, .tiff or .jpeg file format.

From the President

By Sarah Stabenfeldt, SFB President

Dear SFB members,

2024! What a year for the Society For Biomaterials (SFB). This year, we were fortunate to reconvene in-person for the World Biomaterials Congress in Daegu, South Korea. The event highlighted the excellence in biomaterials research across the globe and reinvigorated our community to strengthen and build international collaborations. SFB had an amazing presence – we were able to convene at an impromptu ice cream social (spearheaded by one of our SIG leaderships) and drinks at a SIG mixer. I am looking forward continuing this energy and community building this coming year where we have several exciting events and opportunities.

In a few short weeks, we will host a multi-site 2024 Regional Meetings where biomaterialists in each regional area will gather to share research findings and network. The event is the vision of one of our past-Presidents (Dr. Elizabeth Cossgriff-Hernandez) – the meeting planning was realized by our National Symposia Chair, Dr. Anita Shukla, (Brown University), who coordinated the following regional chairs:

- Northeastern Region: Drs. Ambika Bajpayee and Abigail Koppes (Northeastern University)
- Midwestern Region: Drs. Steven Eppell and Anirban Sen Gupta (Case Western Reserve University)
- Southeastern Region: Drs. Edward A. Botchwey and Ankur Singh (Georgia Institute of Technology)
- Southwest Region: Drs. Stephanie Seidlits and Janet Zoldan (University of Texas at Austin)
- Western Region: Drs. Nikki Farnsworth (Colorado School of Mines) and Chelsea Magin (University of Colorado Denver | Anschutz)
- Northwestern Region: Drs. Cole DeForest and Jenny Robinson (University of Washington)

This list does not include SFB members who served on the regional planning committees have gone above and beyond to ensure success for each region. Thank you so much for all the hard work and effort in putting together this mosaic of biomaterials research. I can't wait to see this meeting in action!

Our year will move forward with additional virtual events such as the upcoming virtual workshop cohosted with the Materials Research Society (September 24/25) on Artificial intelligence for Biomaterials Design; this workshop will feature many of our outstanding SFB members so be sure to register to learn more.

Lastly, the planning for our 2025 Annual SFB meeting is underway (April 9-12, 2025). This meeting will be particularly momentous as we will celebrate the 50th anniversary of SFB. I look forward to meeting folks in Chicago both reflect and look forward to the next 50yrs for this Society and community.

All the best,

Sarah E. Stabenfeldt, PhD
Professor of Biomedical Engineering, Arizona State University
President of Society for Biomaterials

Member News

NATALIE ARTZI, PH.D., ASSOCIATE PROFESSOR, HARVARD MEDICAL SCHOOL

Dr. Artzi was awarded the 2024 Acta Biomaterialia Silver Medal, recognizing her distinguished leadership and scientific contributions in biomaterials science and engineering. Read more here.

BINATA JODDAR, PH.D., ASSOCIATE PROFESSOR, THE UNIVERSITY OF TEXAS AT EL PASO, BIOMEDICAL ENGINEERING

Suborbital Flight experiment successfully conducted for a NASA project.

Our microfluidic neuronal tissue on a chip flew aboard New Shepard's 24th mission and experienced 180 seconds of microgravity in space on December 19th, 2023.

The chip consisted of human iPSC cell-derived glutamatergic neurons along with embedded electrophysiology microelectrode array-based probes to monitor their activity in microgravity while another set of chips was monitored in parallel under earth to compare both sets of conditions.

A huge shout out to my BME PhD student, Andie Elaine Padilla (first row on the left in the picture below), for her dedication and hard work.

A fantastic experience working with the team at Imec and Space Tango (others in the picture below). Thanks also to colleagues at Blue Origin and NASA.

Pre-launch picture on-site with the entire team.

AIJUN WANG, PH.D., PROFESSOR, UC DAVIS DEPARTMENTS OF SURGERY AND BIOMEDICAL ENGINEERING

A $15 million grant award for a Phase 2 clinical trial. A team of UC Davis Health researchers, led by pioneering fetal surgeon Diana Farmer and bioengineer Aijun Wang, has been awarded nearly $15 million for groundbreaking work on a spina bifida treatment. The funding will allow the team to carry out phase 2 of a clinical trial that tests the first stem cell treatment for the birth defect. Details can be found here.

HO-WOOK JUN, PH.D., PROFESSOR, DEPARTMENT OF BIOMEDICAL ENGINEERING, UNIVERSITY OF ALABAMA AT BIRMINGHAM

An article published in Biomaterials (2024, 122450, 10.1016/j.biomaterials.2023.122450) reports on a groundbreaking in vitro 3D three-layer nanomatrix vascular sheet that reflects multiple features of human atherosclerosis has the potential to be a high-throughput functional assay to evaluate drug candidates for the treatment of atherosclerosis. This novel in vitro 3D three-layer nanomatrix vascular sheet with critical atherosclerosis multi-features including endothelial dysfunction, monocyte recruitment, macrophages, extracellular matrix remodeling, smooth muscle cell phenotype transition, inflammatory cytokine secretion, foam cells, and calcification initiation. A patent for this innovative atherosclerosis model was filed and licensed by Endomimetics LLC.

Annual Business Meeting

The Society's Annual Business meeting took place on Wednesday, May 29, 2024 in Daegu, South Korea at the EXCO Conference Center during the 2024 World Biomaterials Congress. Results of the spring election were announced, and the following people have been elected as officers for the SFB Board of Directors:

2024-2025 PRESIDENT-ELECT

Joyce Wong, PhD, Boston University

2024-2025 MEMBER-AT-LARGE

Kyle Lampe, PhD, University of Virginia

In addition, the Bylaws Amendments presented to the membership for approval passed, and members were elected to the 2024-2025 Awards, Ceremonies and Nominations Committee. The following were elected by the members present: Daniel Alge, Natalie Artzi, E. Thomas Pashuck, and Tatiana Segura.

Bioengineering at Northeastern

A LEADER IN PRACTICAL TRAINING AND RESEARCH

By Ambika Bajpayee and Abraham Joy

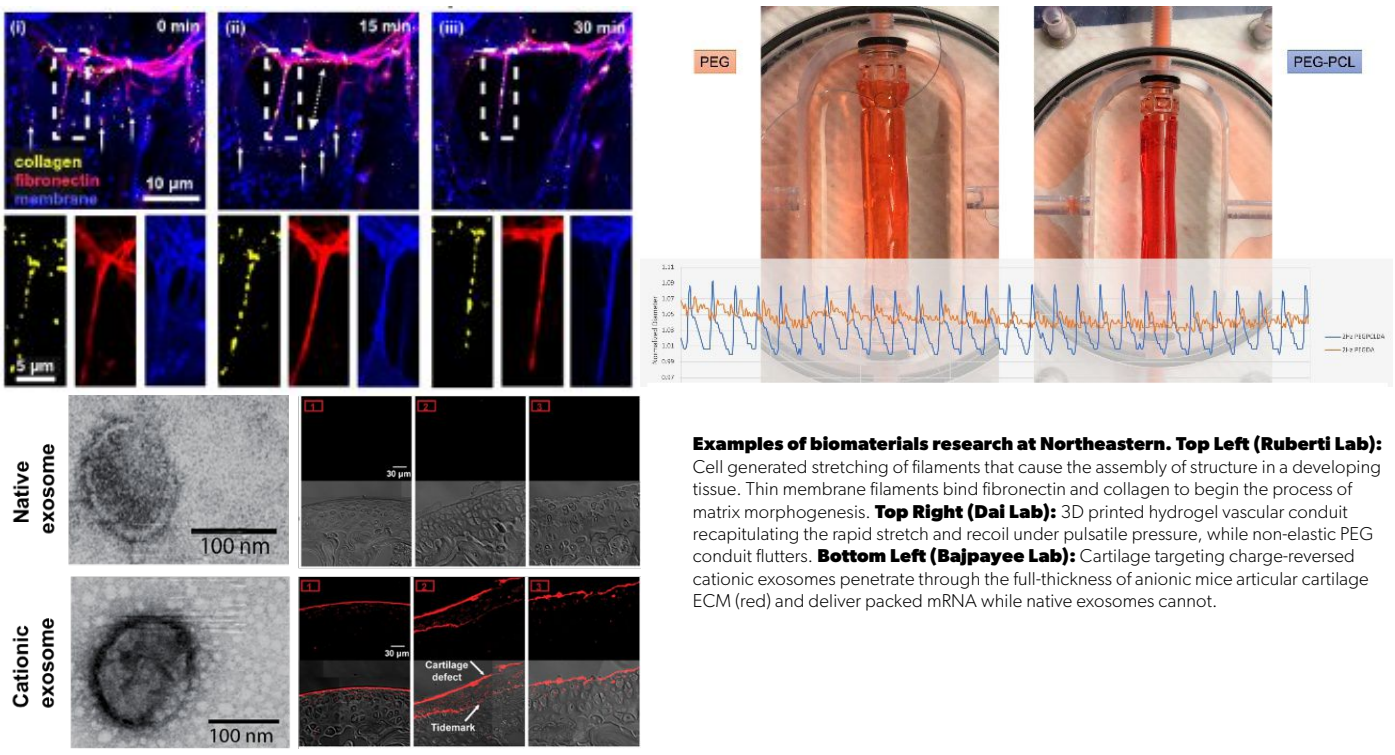
The Department of Bioengineering at Northeastern University stands today as a leader in practical training for undergraduate students and as a strong graduate research program. The roots of the department can be traced back to the early 2000s when the University recognized the burgeoning potential of biomedical engineering, especially in the dynamic ecosystem of the Boston area. In early 2014, Profs. Lee Makowski of Electrical Engineering, Jeffrey Ruberti of Mechanical Engineering, and Anand Asthagiri of Chemical Engineering came together to start an interdisciplinary program in bioengineering and the department was officially founded. Since then, the department has rapidly expanded under the chairmanship of Prof. Makowski and now comprises of about 600 undergraduates, 200 graduate students, and 30 core faculty specializing in tissue engineering, regenerative medicine, drug delivery, systems biology, mechanobiology, bioimaging, molecular engineering and single-cell proteomics. These focus areas reflect the department's commitment to addressing the most pressing contemporary challenges in medicine and healthcare through innovative engineering solutions.

A STRONG PRESENCE

The department has a strong presence in translational biomaterials research. Prof. Jeffrey Ruberti is known for his work in collagen mechanochemistry and the potential use of collagen as a therapeutic material. His early investigations revealing the effect of mechanical tension on the enzymatic susceptibility of collagen showed the potential for force-controlled remodeling in soft-tissues and in engineered extracellular matrix. Subsequently, he has shown that the assembly of collagen is also force dependent through flow-induced crystallization. Taken together, the work suggests that collagen can be delivered as a mechanotherapeutic to repair damaged connective tissue such as ligaments and tendons. He has recently demonstrated that collagen alone can be used to accelerate the repair of rotator cuff. His company, BrilliantStrings Therapeutics is using these discoveries to bring new treatments to heal difficult soft-tissue injuries.

PIONEERING 3D BIOPRINTING

Prof. Guohao Dai's lab pioneered the 3D bioprinting technology to create multiscale vasculature and perfused



Examples of biomaterials research at Northeastern. Top Left (Ruberti Lab): Cell generated stretching of filaments that cause the assembly of structure in a developing tissue. Thin membrane filaments bind fibronectin and collagen to begin the process of matrix morphogenesis. **Top Right (Dai Lab):** 3D printed hydrogel vascular conduit recapitulating the rapid stretch and recoil under pulsatile pressure, while non-elastic PEG conduit flutters. **Bottom Left (Bajpayee Lab):** Cartilage targeting charge-reversed cationic exosomes penetrate through the full-thickness of anionic mice articular cartilage ECM (red) and deliver packed mRNA while native exosomes cannot.

Bioengineering at Northeastern (Continued)

vascular channels and has applied these to model glioblastoma-vascular interactions in brain tumors. 3D bioprinting is a promising technology to fabricate custom geometries for tissue engineering. However, most bioprintable hydrogels are weak and fragile, difficult to handle and cannot mimetic the mechanical behaviors of the native soft elastic tissues. They have developed a visible light crosslinked, single-network, elastic and biocompatible hydrogel system that allows its use for bioprinting of soft tissues. The vascular conduits made of this hydrogel effectively recapitulate the rapid stretch and recoil under the pulsatile pressure from 1 to 3 Hz frequency, which can activate all SMC mechano-activated transcription factors and induce a contractile SMC phenotype to consistently upregulate the core contractile transcription factors and proteins.

Prof. Ambika Bajpayee's lab is a pioneer in *bio-electroceuticals* research. She has designed bioinspired electrically charged biomaterials as nanocarriers for applications in therapeutics delivery and biomedical imaging of complex and charged biological environments. By taking advantage of native electric fields of the body, she has developed tuned biomaterials for targeted biotherapeutics delivery. For decades, the charged environments in the body such as musculoskeletal joint tissues, gastrointestinal tract, and the eye, have been thought of as barriers to drug delivery. Prof. Bajpayee's research (www.bajpayeelab.com) has transformed this view into one that treats the body's inherent electric fields as an opportunity to rationally design cationic carriers based on a target tissue's fixed negative charge density. Prof. Bajpayee is co-chairing the Northeast Chapter of the Society for Biomaterials meeting at Northeastern University in the Fall of 2024.

CELEBRATING 10 YEARS

This year, the department celebrated its 10th year anniversary and Prof. Makowski passed the leadership baton to Prof. Abraham Joy, a leading polymer scientist focusing on biomaterial synthesis for drug delivery. As the new chair, Prof. Joy will continue to grow the research program into a world leading center for translational medicine that will bring new biomedical technologies from bench to clinic while training practically oriented scientists and engineers, engaging with the pharmaceutical industry and tapping the local entrepreneurial ecosystem.

CALLING ALL BOOKWORMS!

If you'd like to contribute a review of your recent favorite read to the ***Biomaterials Forum***, send it for consideration to the Editor at ***Roger_narayan@ncsu.edu***. If it's approved, it will be published in a future Forum Book Review column!

PFAS Bans Could Cripple Medical Device Industry

By Carl G. Simon, Jr., PhD

Per- and polyfluoroalkyl substances (PFAS) are a class of chemicals that are under scrutiny due to concerns regarding toxicity and that are essential for the medical device industry. The American Institute of Medical and Biological Engineering (AIMBE) Industry Council held a "Roundtable on PFAS For Medical Device Industry" on January 30, 2024 at their headquarters in Washington, DC. The goal of the Roundtable was to gather industry (device manufacturers, raw material suppliers), users (surgeons), academia and government (FDA, EPA, NIST) to discuss the impact of PFAS supply chain issues and pending regulatory changes. In addition, a Congressional Lunch Briefing entitled "PFAS in Medical Devices — Essential for Life-Saving Health Care" was held on January 31, 2024 at the Rayburn House Office Building in Washington, DC. The goal of the Briefing was to inform lawmakers about the essential role of PFAS in medical devices so that they will be considered when crafting laws. Many factors around PFAS use in medical devices were discussed during these important meetings. This article represents a brief summary of these discussions.

Discussion started with two problematic PFAS chemicals, perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS), which are surfactants previously used in firefighting foams. PFOA and PFOS do not degrade in the environment within a reasonable time, have been found in drinking water and are suspected toxins. Due to these toxicity concerns, there is a movement to ban PFAS. PFAS are defined as any molecule with a fully fluorinated carbon (-CF2- or CF3) and includes >12,000 compounds. This broad definition is based on chemical structure and does not consider water solubility, toxicity or biocompatibility. PFAS are found throughout society, including semiconductors, phones, cars, planes, batteries, food packaging, water-resistant clothing, non-stick cookware and dental floss. Prozac (fluoxetine) is a PFAS.

It was pointed out that PFAS are used in tens of thousands of medical devices and are implanted into tens of millions of patients each year. Many fluorinated polymers, such as polytetrafluoroethylene (PTFE, Teflon), fluorinated ethylene propylene (FEP) and ethylene tetrafluoroethylene (ETFE), which are PFAS, are used in devices such as pacemakers, defibrillators, heart valves, guidewires, stents, catheters and ocular implants. Fluoropolymers possess special properties that make them ideal for implants. For example, PTFE has the highest lubricity of any known polymer making it especially useful in guidewires where slipperiness is key. PTFE has many additional properties that make it essential in biomedical devices: 1) highly stable in the body; 2) provides an ion barrier to protect wires from degradation; 3) sturdiness; 4) processability such that it can be made into thin films and coatings for product miniaturization; 5) flexible so that it does not crack or delaminate under stress; 6) high electrical resistance for coating wires; 7) low refractive index; 8) does not oxidize; and 9) does not cause blood coagulation. Fluorine is unique since it is the most electronegative atom in the periodic table, which enables it to impart stability, lubricity and other special properties to fluoropolymers.

An update on legislative actions noted that legislatures are proposing PFAS bans that could cripple the medical device industry. Maine and the European Union are passing laws that will ban PFAS by 2030 and 2040, respectively. Minnesota, Massachusetts, Illinois and Tennessee are also considering bans. There are currently no materials that possess the special properties of fluoropolymers (PTFE, FEP, ETFE) and that can replace their use in medical devices. Even if alternate materials were available, substituting them into existing devices would require years of safety testing and there would be no guarantee of success. Safety testing of medical devices is a costly and lengthy process (many years).

Most importantly, it was mentioned that there is no evidence of toxicity of fluoropolymers used in medical implants — fluoropolymers such as PTFE have been implanted into more than a 100 million patients since the 1950s and are considered a non-toxic, biocompatible polymer of low concern.[1] Fluoropolymers are highly stable, are not water soluble and do not pose a risk of getting into the water supply. It was suggested that it may be more appropriate for legislatures to regulate chemicals based on their individual risks and benefits instead of applying one rule to all 12,000+ PFAS compounds. Indeed, EPA proposed on February 8 2024 to list 9 specific PFAS compounds as hazardous, including PFOA and PFOS.

It was noted that chemicals are not typically regulated in broad classes of one-rule-for-all. For example, benzene is a regulated toxic chemical that consists of a 6-membered aromatic carbon ring. However, it would not make sense to regulate all chemicals with aromatic rings as a broad class, since only some of these chemicals are toxic. Estrogen is a natural hormone found in all people that has an aromatic ring. Most proteins have aromatic rings, since the amino acids phenylalanine, tryptophan and tyrosine have aromatic rings.

There was dialogue that FDA is considering how PFAS bans could affect operations at Center for Devices and Radiological Health (CDRH). There are currently 238,000 devices approved at CDRH with more than 1 million SKUs. There is no easy way to determine which products have PFAS. It was estimated that 99% of PFAS in medical devices may be PTFE and FEP. Replacing PFAS in devices with alternate materials would pose a tremendous burden in re-testing and re-review of an estimated 10,000 approved devices.

PFAS toxicity is a complex issue with many aspects beyond that covered in this brief article. Hopefully, a path forward can be found that does not result in medical device shortages in the coming years.

REFERENCES

1. Henry BJ, Carlin JP, Hammerschmidt JA, Buck RC, Buxton LW, Fiedler H, Seed J, Hernandez O. A critical review of the application of polymer of low concern and regulatory criteria to fluoropolymers. Integr Environ Assess Manag 2018, 14(3):316-334. doi: 10.1002/ieam.4035.

Contact: Carl Simon, carl.simon@nist.gov

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NOMINATION DEADLINE

The SFB Awards, Ceremonies, and Nominations Committee is currently accepting nominations for all 2025 awards and for the positions of President-Elect, Secretary/Treasurer-Elect, and Member-at-Large for the 2025-2026 term.

ALL nomination packages due no later than Friday, September 20th!

2025 AWARDS:

- FOUNDERS AWARD
- C. WILLIAM HALL AWARD
- THE SFB AWARD FOR SERVICE
- TECHNOLOGY INNOVATION, AND DEVELOPMENT AWARD
- DIVERSITY, EQUITY, AND INCLUSION (DEI) AWARD
- MID-CAREER AWARD
- YOUNG INVESTIGATOR AWARD
- CLEMSON AWARD FOR BASIC RESEARCH
- CLEMSON AWARD FOR APPLIED RESEARCH
- CLEMSON AWARD FOR CONTRIBUTIONS TO THE LITERATURE
- STUDENT AWARDS FOR OUTSTANDING RESEARCH
  - PHD, MASTERS, UNDERGRADUATE CATEGORIES
- OUTSTANDING RESEARCH BY A HOSPITAL INTERN, RESIDENT, OR CLINICAL FELLOW AWARD

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Send your nominations to Shena Seppanen:
sseppanen@biomaterials.org