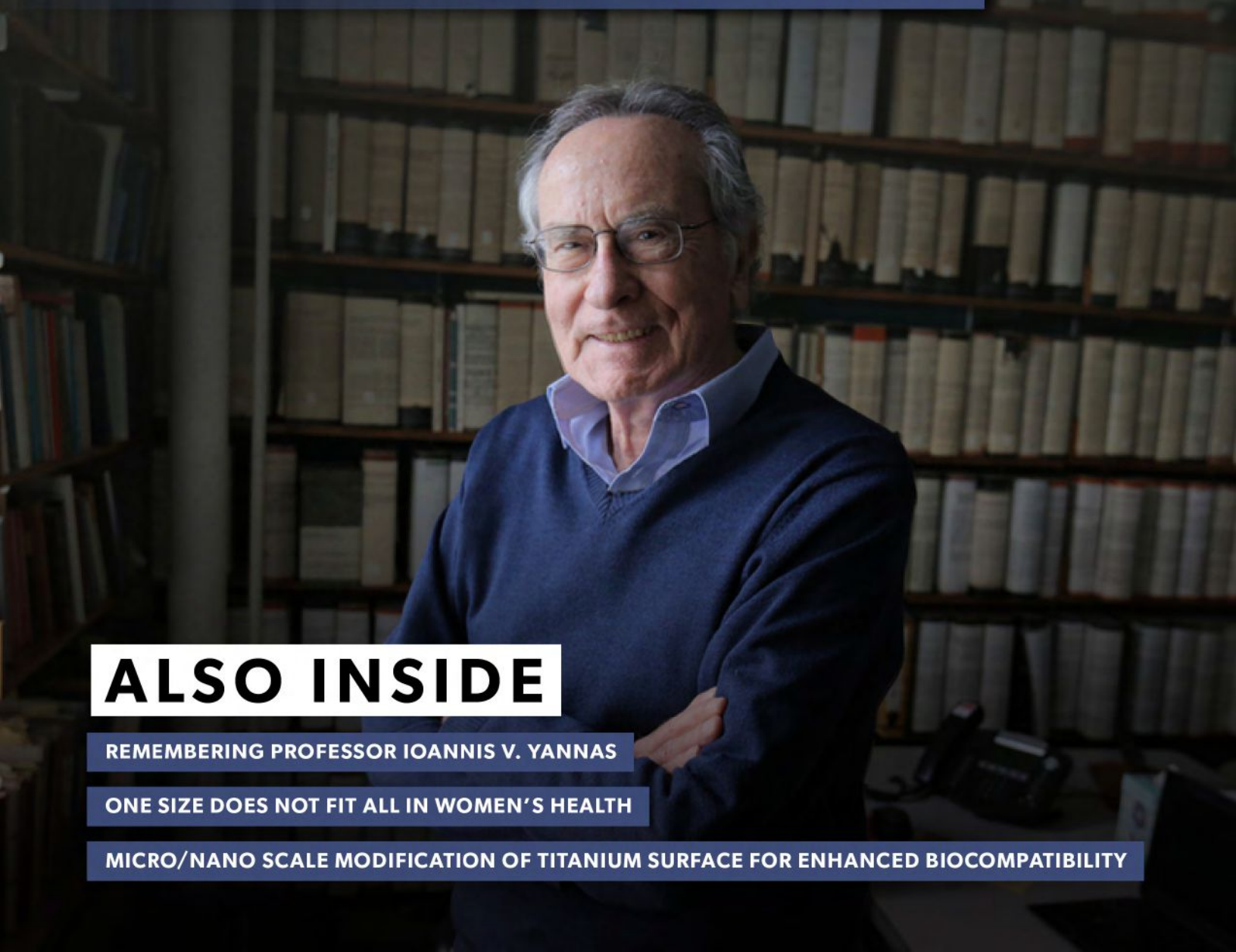
IOANNIS YANNAS WAS A PHYSICAL CHEMIST AND ENGINEER KNOWN FOR THE INVENTION OF ARTIFICIAL SKIN FOR THE TREATMENT OF SEVERE BURNS. "THE IMPACT OF HIS INVENTIONS, AND HIS LEGACY ON THE FIELD OF BIOENGINEERING WAS IMMENSE," SAID PROFESSOR JOHN HART, HEAD OF THE DEPARTMENT OF MECHANICAL ENGINEERING AT MIT.

BIOMATERIALS FORUM

OFFICIAL NEWSLETTER OF THE SOCIETY FOR BIOMATERIALS

FOURTH QUARTER 2025 • VOLUME 47, ISSUE 4



ALSO INSIDE

REMEMBERING PROFESSOR IOANNIS V. YANNAS

ONE SIZE DOES NOT FIT ALL IN WOMEN'S HEALTH

MICRO/NANO SCALE MODIFICATION OF TITANIUM SURFACE FOR ENHANCED BIOCOMPATIBILITY

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Contact information can be found on individual SIG pages as found **here**.



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ON THE COVER

Ioannis Yannas was a physical chemist and engineer known for the invention of artificial skin for the treatment of severe burns. "The impact of his inventions, and his legacy on the field of bioengineering was immense," says Professor John Hart, head of the Department of Mechanical Engineering at MIT.

Photo: John Freidah/MIT MechE

From the Editor

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



Welcome to the Fourth Quarter issue of the Biomaterials Forum! Joyce Wong's President's Message emphasizes the importance of building the community by re-energizing our student chapters and describes a pilot mentoring program in which industry leaders mentor undergraduate members of the society in career and professional development.

The AIMBE Update describes the selection of the 2026 Emerging Leaders and the launch of the Biomedical Engineering Multidisciplinary Alliance (BEMA) Roundtable, which held its first meeting on Nov. 3, 2025, focusing on medical device supply chain resilience. The update includes a discussion of changes at the NIH, particularly the shift away from paylines toward NIH strategic plans, priorities and budgets.

This issue also includes a tribute to Professor Ioannis Yannas, a pioneer of regenerative medicine who invented artificial skin for severe burn treatment. Working with John Burke of Massachusetts General Hospital, Yannas developed an artificial skin product called Integra, which remains widely used for severe burns, plastic surgery and chronic diabetic wounds. In addition to being elected to the National Academy of Medicine (1987), National Inventors Hall of Fame (2015) and National Academy of Engineering (2017), Yannas received the Society For Biomaterials Founders Award (1982) and Clemson Award (1992).

Shreya Raghavan and Erika Moore's paper from the NSF ElevateHER Conference demonstrates that one-size-fits-all biomedical engineering designs lead to suboptimal outcomes for women, including higher artificial hip joint failure rates, lower immunotherapy success rates and inaccurate wearable health tracker data. The paper provides actionable steps to revolutionize women's health by tailoring biomedical technologies to physiological differences. Aniruddha Vijay Savargaonkar's article considers the development and evaluation of copper-modified titania nanotube arrays; this biomimetic multi-scale structure shows strong potential for use in orthopaedic implants.

The Student News reviews a recent survey of students and postdocs that examines how students are drawn to the biomaterials field and their views on future directions, including AI-driven materials design, smart biomaterials, sustainability and immunomodulatory platforms.

The Member News highlights recent achievements from Guillermo Ameer, who developed the citrate-based bone regeneration device Citregraft that was used in its first surgical case; Bingyun Li, who was inducted into the ICORS College of Fellows and received West Virginia University's Chancellor's Mentor Award; Mohini Kamra, who started as a faculty member at the University of South Alabama and established a research lab focused on women's health biomaterials; and Leo Wang, who received the NIH DP5 Early Independence Award to develop biomaterials for scar treatment through hair follicle regeneration.

The Orthopaedic Biomaterials SIG presents a clinical case study by Patrick John Batol and Roche C. de Guzman, which demonstrates how 3D CT imaging, CAD modeling and 3D-printed polylactic acid surgical guides enabled precise mandibular ameloblastoma resection and reconstruction. This case study highlighted the integration of digital planning tools and orthopedic biomaterials for patient-specific surgical activities.

The Industry News report indicates the U.S. biomaterials market has projected growth of 8-11 percent through 2034-35, which is driven by increased demand in the orthopedic, cardiovascular and tissue engineering fields. The report highlights the growth of biomaterials industry hubs in California, Washington, Texas, Massachusetts and the Midwest.

Please feel free to reach out to me at roger_narayan@ncsu.edu if your group would like to share biomaterials research, education, translation and outreach activities that may be of interest to the Society For Biomaterials community. The submission of news items, updates, images and artwork is always welcome.

From the President

By Joyce Wong, SFB President



Dear SFB Members,

As 2025 ends and we embrace a new year ahead, I reflect on the unique challenges we have all faced this past year. We have all been pushed and tested beyond our limits, yet we have shown resilience and have come together in these hard times.

I would like to first acknowledge the recent passing of our dear colleague, Dr. Yanni Yannas from MIT. This issue of ***Biomaterials Forum*** has a remembrance of the profound impact Dr. Yannas had on biomaterials and tissue engineering. I was fortunate to have taken a course with him during my graduate studies, and when I started my faculty position, he gave me invaluable advice on teaching. He will be missed dearly, yet his legacy lives on through his seminal contributions and the many lives he has touched.

As we continue to navigate these unprecedented and uncertain times, we must continue to build community and support each other. I highlighted in my brief remarks at the business meeting this past April at the Chicago national meeting that we can help to build community by re-energizing our SFB Student Chapters across the country. I am pleased to report that we have received an unprecedented ***nine*** applications for Biomaterials Day that span the nation. I would like to thank Dr. Erika Moore and her committee (Education & Professional Development Committee) for their extraordinary hard work and efforts which have paid off in this incredible turnout of student chapter engagement. We hope that in the future we will receive ***even more*** applications for Biomaterials Day, and we continue to encourage those institutions who do not yet have SFB Student Chapters to reach out to existing chapters for help.

I would also like to highlight the work of Dr. Ngan Huang who, as head of a special task force on Strategic Liaison Engagement, has launched a pilot mentoring program where industry leaders mentor undergraduate SFB members in career and professional development. The pilot program has first launched in Boston and Phoenix, and I will report more at the 2026 Annual Meeting in Atlanta on how we can expand and scale this program.

Thank you to everyone who submitted their abstracts to our next annual meeting, "***Biomaterials at the Crossroads: Connecting Science, Industry, and Innovation***," scheduled for March 25-28, 2026, in Atlanta GA, organized by co-chairs Dr. Angela Throm and Dr. Susan Thomas. They are working hard to make this a memorable meeting. If you missed the abstract deadline, you still have a chance to submit to our late-breaking poster session. Please keep an eye on the website for updates for registration and more information on the exciting program!

Our community extends beyond the United States, and I am mindful that our international colleagues are finding it increasingly difficult to attend our meetings. This is particularly concerning considering the 2028 World Biomaterials Congress will be held in Washington, D.C. While SFB is working to mitigate some of these concerns, it is important for us all to continue to educate the lay public and policymakers the value in free exchange of ideas to foster innovation.

I also would like to thank the SFB Council Members, the Board of Directors, SFB staff and all committee members for their hard work this past year. You all play a critical role in ensuring SFB is the leading organization in biomaterials.

I am excited to see what 2026 brings because I know that together we are strongest.

Yours in solidarity and with gratitude,

Joyce Y. Wong, PhD
Inaugural Term Distinguished Professor of Engineering
Professor of Biomedical Engineering and Materials Science & Engineering, Boston University
President of Society For Biomaterials

AIMBE Updates

By Dawn Beraud, PhD

AIMBE ANNOUNCES 2026 EMERGING LEADERS

AIMBE is delighted to announce the selection of its 2026 Emerging Leaders in recognition of their distinguished achievements in medical and biological engineering. The goal of AIMBE's Emerging Leaders Program is to increase AIMBE's engagement with exceptional professionals that are underrepresented in medical and biological engineering (MBE), recognize outstanding rising leaders in MBE, and serve as a pathway for leaders to AIMBE's College of Fellows. Emerging leaders will have a unique opportunity to network and engage with AIMBE Fellows at the Annual Event and receive direct mentoring from current AIMBE Fellows. The Emerging Leaders will be formally honored during AIMBE's Annual Event on April 11-13, 2026. Click here to view the press release.

AIMBE LAUNCHES THE BIOMEDICAL ENGINEERING MULTIDISCIPLINARY ALLIANCE (BEMA) ROUNDTABLE

AIMBE is pleased to announce the launch of the BEMA Roundtable, an initiative that brings together leading experts from industry, academia and government to address pressing challenges in the biotechnology sector. Originally convened by the National Academies as the Roundtable on Biomedical Engineering Materials and Applications, with leadership from several AIMBE Fellows, that version of BEMA was sunset in 2024.

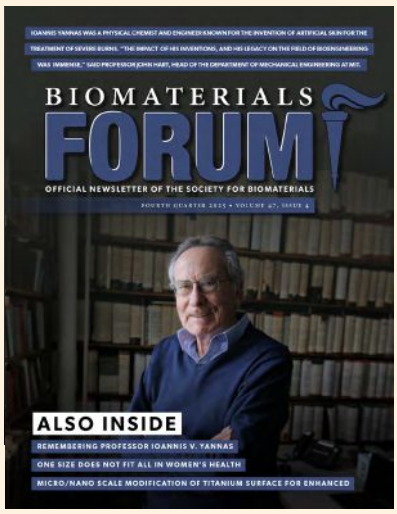
On Nov. 3, 2025, AIMBE hosted its first BEMA Roundtable on "Building Supply Chain Resilience in the Medical Device Industry" in Washington, D.C. This event convened more than 30 cross-sector experts across 20 different organizations for a full day of presentations, closed-door discussions and networking. Click here to view the roundtable agenda, which includes our invited speakers, organizations represented by our participants and the AIMBE Fellows who comprised the BEMA Working Committee. AIMBE looks forward to continuing our engagement with the medical and biological engineering community at next year's in-person BEMA Roundtable meetings.

REGISTRATION OPEN FOR AIMBE'S ANNUAL EVENT ON APRIL 11-13, 2026

Register now for AIMBE's 2026 Annual Event on April 11-13, 2026. Join us and network with your esteemed AIMBE friends and colleagues during science policy sessions, special events and timely discussions that advance our field and our shared advocacy mission. We're excited to bring back and expand our popular Research Blitz! These rapid-fire presentations are designed to spark new connections and give attendees a fast-paced look at research across the community. Participation is first-come, first-served, so register now!

Lastly, there has never been a more important time to advocate for science and engineering on Capitol Hill. Register now and sign-up to participate in congressional visits with your Members of Congress and their staff. AIMBE will provide multiple exclusive training sessions only for Fellows with Capitol Hill appointments. ***Early registration is encouraged as space for congressional visits is extremely limited!***

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.

Student News

STUDENT PERSPECTIVES ON BIOMATERIALS

The survey responses highlight ***enthusiastic, forward-thinking and diverse*** viewpoints from students and postdocs across the country.

1. How did students first learn about biomaterials?

Our members discovered biomaterials through personal experiences, graduate research, early internships or foundational coursework.

2. What draws students into biomaterials?

Across responses, students emphasized interdisciplinarity, impact, creativity and the ability to address real clinical challenges.

3. Where do you see the field going?

- **LLMs + Materials Design:** Predictive design pipelines for faster discovery
- **Sustainability Trends:** Increased use of bio-based, degradable and environmentally responsible materials
- **Multifunctional and Smart Biomaterials:** Next-gen materials capable of sensing, responding and adapting to their environment
- **Immunomodulatory Platforms:** More specific, targeted and tunable antigen-specific systems

Testimonials:

- **Mahmood Zabihi (Graduate Student at Texas A&M University):** "The vastness of possibilities and potential applications that biomaterials have had for almost every healthcare complication was (and still is) mesmerizing."
- **Nikolaos Pipis (Postdoc at Seattle Children's Research Institute): "**My interest in biomaterials began in childhood watching lizards regenerate their tails. This sparked a lasting curiosity about how humans might one day repair or regrow their own tissues."
- **Nicholas Fischer (Postdoc at UPenn):** "The interdisciplinary nature – working between engineering, biology and medicine – is what keeps me excited about the field."





Professor Ioannis Yannas, pioneer of regenerative medicine who invented artificial skin for the treatment of severe burns, dies at 90

A beloved member of the Department of Mechanical Engineering for nearly 60 years, Yannas helped save the lives of thousands of burn victims through his research and innovation.

By Anne Wilson | MIT News

Professor Ioannis V. Yannas, SM '59, a physical chemist and engineer known for the invention of artificial skin for the treatment of severe burns, and a longtime member of the MIT faculty, died on Oct. 19 at the age of 90.

"Professor Yannas was a beloved and distinguished colleague, teacher and mentor. The impact of his inventions, and his legacy on the field of bioengineering was immense," said John Hart, the Class of 1922 Professor and head of the Department of Mechanical Engineering.

Yannas, known to friends and colleagues as Yanni, held appointments in the MIT Department of Mechanical Engineering and the Harvard-MIT Program in Health Sciences and Technology. His principal research interest throughout his career was the process of induced organ regeneration used to replace organs that are either severely injured or terminally diseased. His work also advanced the clinical use of collagen tubes to treat peripheral nerve injuries.

In 1969, when Yannas approached the late John Burke of Massachusetts General Hospital to collaborate, Burke took him on a tour of a children's burn unit. "There was a great deal of human misery that was confronting me, and I felt I had to do something about it," said Yannas in later interviews. In 1981, the pair announced their success: an amalgam of a silicone outer sheet over a scaffolding of molecular material drawn from cow tendon and shark cartilage. Offering protection from infection and dehydration, the scaffolding enabled healthy skin cells to grow. Their discovery would be transformative for the treatment of burn victims.

Their artificial skin, patented and now manufactured as Integra, is still widely used on patients with severe and extensive burns, and for other applications including some types of plastic surgery and the treatment of chronic skin wounds commonly suffered by people with diabetes. The groundbreaking advance, which was later recognized as the first example of organ regeneration in adults, had previously been considered impossible.

"Yanni's boldness in attacking a wide array of medical problems, including spinal cord transection, in his investigations of applications of collagen-based implants, inspired others, including myself, to work toward solutions to devastating conditions such as blindness, stroke and spinal cord injury," said Myron Spector, professor emeritus of orthopedic surgery (biomaterials) at Massachusetts General Brigham and Harvard Medical School, and an affiliate of the Harvard-MIT Program in Health Sciences and Technology. Yannas and Spector created several MIT courses together, including 2.79 (Biomaterial-Tissue Interactions).

"As we were talking about the content [for 2.79], Yanni proposed that we codify the cell behavior underlying the tissue response to implants," explained Spector. "Within a short time, we laid out the plan for 'unit cell processes' to offer students a code to decipher the often inconceivably complex cellular processes that not only underlie the tissue response to implants, but that can guide the selection of the tools necessary to engineer medical devices and reveal their targets for treatment. This was all Yanni, taking a fundamental concept, the control volume used in chemical engineering to analyze systems, and applying it to cellular processes in the human body. I since use UCPs myself all the time."



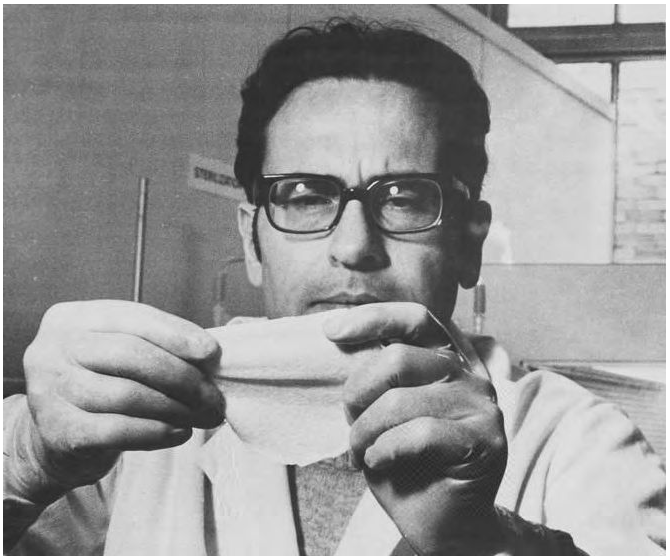
A "failed experiment" became a life-saving discovery by Professor Ioannis Yannas (pictured) and his colleague John Burke when their search for a better way to treat severe burn victims led to the discovery of organ regeneration — thought impossible by the scientific and medical communities at the time — as well as a brand new field of medicine.

Photo: Calvin Campbell/MIT News Office

As a colleague serving as a collaborator in teaching and in research, Spector said Yannas was eager to help and to learn, bold in his thinking, smart in his choices, able to keep his eye

Professor Ioannis Yannas, pioneer of regenerative medicine who invented artificial skin for the treatment of severe burns, dies at 90

on the goal, respectful of students as well as faculty and other colleagues, and selfless. "These are just the traits that we teach our students to look for when seeking the collaborators who are so necessary in science and engineering."



For his discoveries in organ regeneration, Yannas was elected member of the National Academy of Medicine, the National Inventors Hall of Fame, and the National Academy of Engineering. He was also elected fellow of the American Institute of Medical and Biomedical Engineering.

Photo: Calvin Campbell/MIT News Office

Yannas was born on April 14, 1935, in Athens, Greece, where he completed his high school education at Athens College. He received a BA in chemistry at Harvard College in 1957, followed by an MS in chemical engineering from MIT in 1959. After a period of industrial research on polymers at W. R. Grace & Co., in Cambridge, Mass., he attended Princeton University, where he completed an MS degree in 1965 and a PhD in 1966, both in physical chemistry. Yannas joined the MIT faculty immediately thereafter and remained at the Institute for the next 59 years until his passing.

For his discoveries in organ regeneration, Yannas was elected member of the National Academy of Medicine (1987), the National Inventors Hall of Fame (2015), and the National Academy of Engineering (2017). He was also elected Fellow of the American Institute of Medical and Biomedical Engineering.

Further, he was the recipient of many prestigious awards including the Society For Biomaterials Founders Award (1982) and the Society's Clemson Award for Applied Science and Engineering (1992). He was an author of numerous journal articles, and the sole author of the influential book, "Tissue and Organ Regeneration in Adults."

Yannas' work, and 2015 induction into the National Inventors Hall of Fame, was the subject of "Hope Regenerated," a video produced by the MIT Department of Mechanical Engineering. The film chronicles the development of Integra, which was initially characterized as a "failed experiment" but became a life-saving discovery that launched a new field of regenerative medicine.

"My father's relationship with MIT was deeply meaningful to him," said Tania Yannas Kluzak. "He regarded MIT as the ideal partner in his life's work — pioneering lifesaving research in organ regeneration."

Yannas was predeceased by his brother, Pavlos. He is survived by his two children, Tania Kluzak and her husband Gordon, and Alexi Yannas and his wife Maria; his grandchildren — Alexandra, Marina, Sophia, Philippos, and Nefeli; his sister, Elizabeth Sitinas; and many loving relatives and friends. A celebration of life will be announced at a later date.

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ATTENTION MEMBERS!

WE WOULD LOVE TO HEAR FROM YOU.

If you have news to share with *Forum* readers, let us know. Email your news and any photos to info@biomaterials.org and you could be featured in the next issue.

ElevateHER: One Size Does Not Fit All in Women's Health

By Shreya Raghavan, PhD (Texas A&M University); Erika Moore, PhD (University of Maryland)

Artificial hip joints fail more frequently in female patients because the unisex design is not tailored to the differences between men's and women's hip anatomies. Immunotherapy cancer treatment has lower success rates in women than men due to differences in immune response between the sexes. Even popular wearable health tracker devices often fail to adjust for phases of the menstrual cycle or pregnancy, resulting in inaccurate data and false illness reports for healthy female users.

The consequence is sub-optimal care from what should be cutting-edge biomedical technology. "You go to this one-size-fits-all approach, and then you find it doesn't work very well," said Dr. Shreya Raghavan, assistant professor at Texas A&M University's Department of Biomedical Engineering.

This is the problem that Raghavan and Dr. Erika Moore of the University of Maryland seek to address. In a new paper published in Med, they lay out plans for a holistic consideration of women's health and biomedical engineering – an approach that could result in more-effective healthcare for both women and men. The paper is based on their findings as the chairs of the National Science Foundation's ElevateHER Conference, which Texas A&M University hosted in August.

"The goal is to move forward human health for everybody, not just for women. By disaggregating and studying differences in women's health, you're now finding out information about men and women, and now you can tailor things for each," said Raghavan.

The paper presents a list of clear and detailed actions to revolutionize women's health, identifying key research areas and calling for open communication between fragmented engineering and medical fields. "Our work and the conference are hoping to address the silos and separations that we see happening around women's health and to coalesce effort so that together we can make a more substantial impact in women's health faster," said Moore.

Many biomedical engineering breakthroughs remain unused in women's health due to a lack of awareness and limited focus on reproductive health. "A striking example of this phenomenon is seen when breakthroughs in biomaterials for bone repair and orthopedic health are not immediately recognized as beneficial for addressing bone density loss associated with menopause," the paper states.

Biomedical technologies that are applied to women's health often perform poorly because they are not tailored to women's physiology. "Immunotherapy is much more effective in men than it is in women because we don't ever think of immunity as context dependent," explained Raghavan. Men, who have a weaker immune response than women on average, respond well to immunotherapy. Female patients' stronger immune systems receive less help from boosting the immune system but have a far better response to treatments that enhance the body's ability to recognize tumors. Tailoring treatment to the patient's sex would result in more effective care for all cancer patients.



Dr. Erika Moore, left, and Dr. Shreya Raghavan at the National Science Foundation's ElevateHER Conference, hosted by Texas A&M University in August

Even consumer health goods suffer from the one-size-fits-all approach. Raghavan points to wearable health tracker devices,

ElevateHER: One Size Does Not Fit All in Women's Health

which track users' biometrics like heart rate and temperature. Despite manufacturers' resources and desire to succeed in a competitive market, some of the most popular devices take generations of development before they address simple issues that dramatically decrease the usability for women. Female customers complain of devices sending illness alerts simply because of the natural temperature fluctuations during menstrual cycle phases or repeatedly warning expectant mothers that they are experiencing unhealthy weight gain because the device has no way to mark the user as pregnant.

"My biggest hope from publishing this paper is that we'll have tangible action," said Raghavan, "We put this paper together so all the stakeholders can find action items: What are the most pressing problems in health, especially women's health? Where do we need to invest?"

The future now rests in communicating and raising awareness – with isolated researchers and clinicians, with the public and with the prospective students who will become the next generation of biomedical engineers. "The science is there. There's a critical mass now, driven by many early engineers who pioneered and championed engineering for women's health. Now, it's all about continued organization and action," said Raghavan, "I don't think we have to wait 10 more years to see results. I think we're seeing it in action already, but there's always more work to be done."

At Texas A&M University's biomedical engineering department, the future is already arriving. Raghavan and Moore plan for the next ElevateHER Conference to include the students and trainees who will go on to create the next wave of biomedical breakthroughs.

ADVANCING BIOMATERIAL INNOVATION

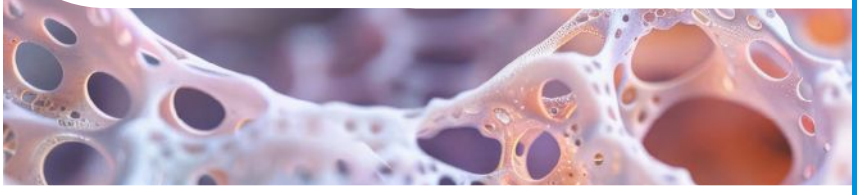


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Micro/Nano Scale Modification Of Titanium Surface for Enhanced Biocompatibility

By Aniruddha Vijay Savargaonkar, PhD

Titanium and its alloys are a well-established class of materials used to fabricate implants thanks to their excellent mechanical properties including relatively low young's modulus to counteract stress shielding, good corrosion resistance due to the instantaneously forming oxide layer and biocompatibility.[1,2] However, this oxide layer which allows for corrosion resistance also is bioinert in nature, wherein it does not react with the host environment which results in decreased integration with the body,[3,4] leading to issues such as implant loosening, bacterial infection and encapsulation of implant due to lack of interaction with the body. Hence, to achieve long term success, it is important to make the implant surface more bioactive through modifications of the surface.

Orthopedic implants are one of the most essential implants for the body as they affect the quality of life of patients with bone and cartilage diseases. According to the Centers for Disease Control and Prevention (CDC), the rate of total knee replacement increased by 86% for men and 99% for women aged 45 and over between the years 2000 and 2015, whereas the rate of total hip replacement increased from 12% to 17% for patients aged 45 and over between the years 2000 and 2010.[5] In my doctoral research, I developed two major types of modified titanium surfaces which can be used to fabricate orthopedic implants – copper-modified titania nanotube arrays and alkali-treated nanostructured, microporous titanium surfaces. Both types of modified titanium surfaces demonstrated enhanced antibacterial properties, enhanced mesenchymal stem cell growth and differentiation and hemocompatibility. In this article, I will be focusing on the mesenchymal stem cell interactions and osteogenic differentiation on the copper-modified titania nanotube arrays.

Bone has hierarchical structure that ranges from the micro- to the nanoscale, a multi-scale structure has shown greater promise as it is biomimetic and provides favorable environment for growth and differentiation of mesenchymal stem cells as well as enable nutrient transport.[6] Hence, different nanoscale topographies have been investigated, such as nanowires, nanotubes, nanoflowers, nanorods and nanoribbons[7–11] at the nano scale, as well as microscale topographies such as honeycomb-shape, parallel groove formation and micro-pits.[12–14] Implant surfaces modified with nanoparticle layers have also shown a higher growth of mesenchymal stem cells.[2,15]

Titania nanotubes are a very interesting surface modification which have demonstrated an extensive range of favorable outcomes when interacting with bacteria, mesenchymal cell and blood. Nanotube surfaces with different diameters that have been annealed at different temperatures have demonstrated a reduced number of live and dead bacteria adhered on the surfaces.[1] Titania nanotube surfaces are also hydrophilic and have demonstrated enhanced osseointegration.[16] Research shows that titania nanotube surfaces with an 80 nm diameter have an optimum proliferation and differentiation of osteoblasts.[17]

Titania nanotubes used to prepare copper-modified titania nanotube (NTCu) arrays were fabricated using an anodization and annealing process on commercially pure medical grade titanium foils. Anodization was carried out using an electrolyte solution of diethylene glycol, DI water and hydrofluoric acid. After anodization, the surfaces were annealed at 530°C in an oxygen ambient environment. The copper modification was carried out using a novel physical vapor deposition method.[18] Nanotube surfaces were modified with copper to enhance their antibacterial properties as well as improve their osteogenic differentiation capabilities. The copper modification technique is in the process of getting patented, hence, it cannot be described in detail. The surfaces were characterized using SEM, XPS, XRD and Goniometry for their surface topography, surface chemistry and surface wettability, respectively.

Human Adipose Derived Stem Cells were seeding on the surfaces and their adhesion and proliferation were investigated after four and seven days of culture using fluorescence microscopy and SEM. NTCu surfaces demonstrated adhesion after four days of culture and increased proliferation between four and seven days of culture. Cell growth on NTCu as well as unmodified nanotube surfaces was elongated as compared to the spherical growth observed on titanium surface. After seven days of ADSC culture on surfaces, osteogenesis was induced by providing osteogenic media to cells for differentiation to osteoblasts. Osteogenic media comprised of growth media plus dexamethasone, β–glycerophosphate, and ascorbic acid. The additives have to be added to the growth media because the α – MEM media allows for rapid proliferation but depresses the differentiation markers.[19,20]

ADSC differentiation to osteogenic lineages was evaluated through immunofluorescence microscopy and protein-based assays. Osteocalcin (OCN) is a protein secreted for bone matrix formation. The OCN secretion was evaluated using immunofluorescence microscopy after weeks one and three of culture. Despite a lower cell count, NTCu surfaces demonstrated an enhanced OCN expression from week one to week three of culture, showing the increase in osteogenic differentiation. The SEM images also demonstrated complete coverage of cells on the surfaces showing the elevated biocompatibility of the modified titanium surfaces. The NTCu surfaces demonstrated enhanced osteogenic differentiation and have the potential of being used for fabrication of orthopedic implants.

Micro/Nano Scale Modification Of Titanium Surface for Enhanced Biocompatibility

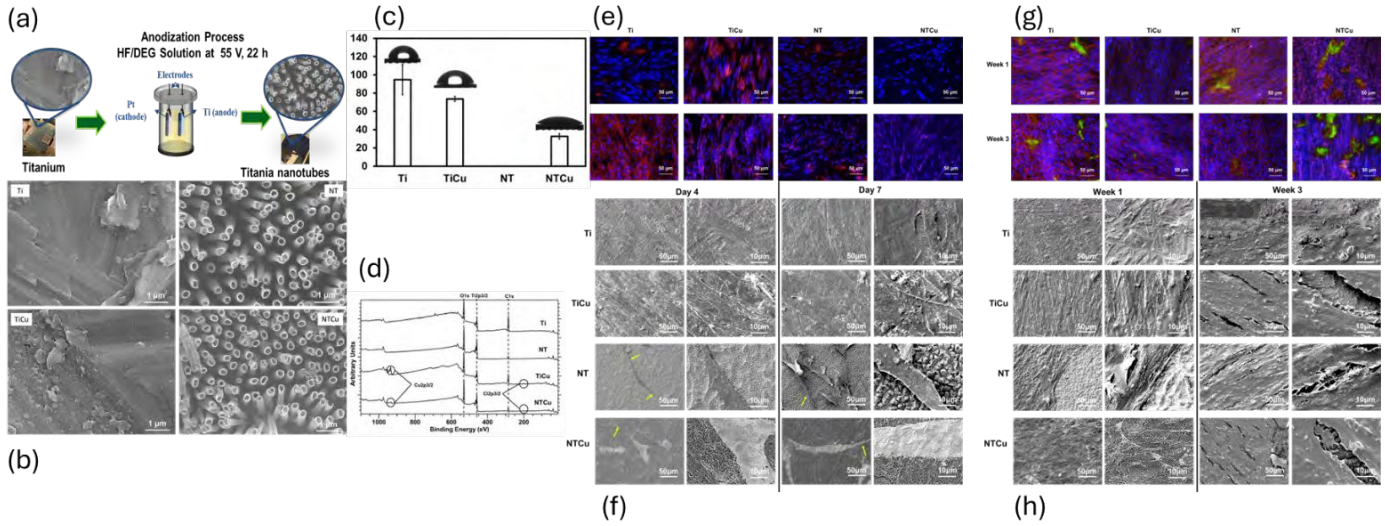


Figure 1: (a) Anodization process to fabricate titania nanotubes. (b) Surface topography of different surfaces using SEM. (c) Contact angle measurements for different surfaces. (d) Surface chemistry for different surfaces using XPS. (e) Fluorescence microscopy images and (f) SEM images showing the mesenchymal stem-cell adhesion and proliferation after four and seven days of culture. (g) Immunofluorescence microscopy and (h) SEM images showing the osteogenic differentiation of mesenchymal stem cells on different surfaces after days 14 (week one) and days 28 (week three) of culture.

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Integrating 3D Technologies and Orthopaedic Biomaterials in a Patient-Specific Surgical Workflow: Application in Mandibular Reconstruction

By Patrick John Batol, MD, Head and Neck Surgeon, Batol Multispecialty Clinic, Bataan, Philippines; and Roche C. de Guzman, PhD, Associate Professor, Department of Engineering, Hofstra University, New York, USA

From the *Orthopaedic Biomaterial SIG*

The convergence of digital planning tools and orthopaedic biomaterials is revolutionizing reconstructive surgery, enabling precise, patient-specific interventions that were previously unattainable. This case study presents a multidisciplinary approach to mandibular ameloblastoma resection and reconstruction, highlighting the synergistic use of 3D imaging, CAD modeling and 3D printing to guide surgical execution and biomaterial integration.

A 45-year-old male is presented with a seven-year history of a progressively enlarging, painless mandibular mass. Clinical examination and 3D-computed tomography (CT) imaging revealed a multilobulated ameloblastoma, crossing the midline and causing extensive osteolytic destruction (Figure 1). The lesion was classified as BSB-FOM under Urken's system,[1] indicating bilateral involvement of the mandibular body and extension into the floor of the mouth; an anatomical challenge requiring precise oncologic resection and good reconstructive planning to improve outcome.

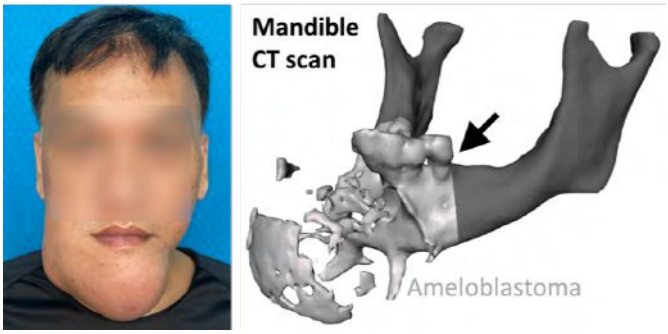


Figure 1. *Left*: Macroscopic appearance of the ameloblastoma mandibular tumor. *Right*: CT image of the mandible bone indicating planned regions of excision (in light gray with arrow of the border).

To address this complexity, the surgical team employed a digital workflow beginning with high-resolution 3D CT scans. These scans were used to generate accurate anatomical models of the mandible and fibula, which were then imported into computer-aided design (CAD) softwares. Using these models, the team designed patient-specific cutting guides for both mandibular resection and fibular osteotomy, as well as a mandibular tray stabilizer to assist in post-resection alignment (Figure 2). The cutting guides were fabricated using fused deposition modeling (FDM) 3D printing with polylactic acid (PLA) filaments – a biodegradable and biocompatible polymer well-suited for surgical planning tools due to its dimensional stability and ease of sterilization. [2]

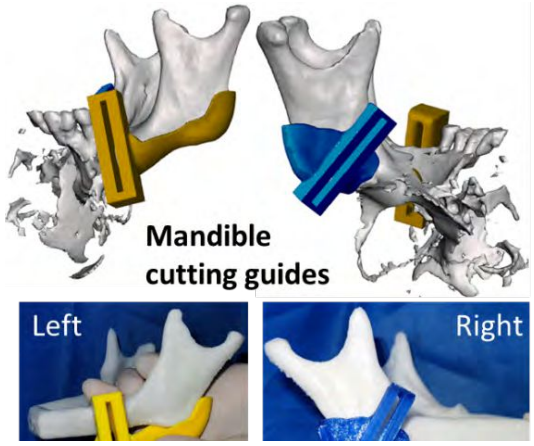


Figure 2. CAD models and 3D-printed mandible cutting guides (yellow and blue representing the left and right sides, respectively).

During surgery, the PLA guides were positioned *in situ* to direct the excision of the affected mandibular segments with 1-cm oncologic margins. The guides ensured stability and minimal deviation[3] from the planned cuts (Figure 3), which preserved critical anatomical structures and optimized the fit for subsequent graft placement. Following resection, the mandibular bone defect was stabilized using the custom tray stabilizer and a titanium reconstruction plate, secured by wires (Figure 4). The stabilizer, designed via CAD modeling and 3D printed using PLA, maintained spatial orientation of the remaining bone segments and served as a mechanical support.

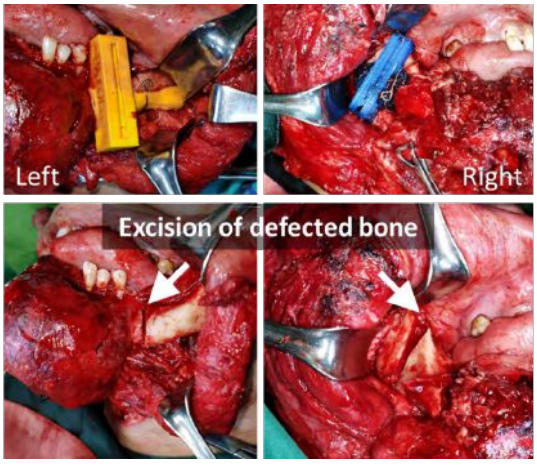


Figure 3. *Top*: Before, and *bottom*: after the excision of the affected mandible using the cutting guides *in situ*.

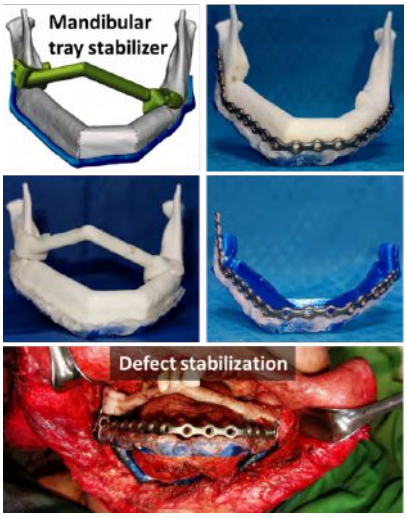


Figure 4. Stabilization of the bone defect after cutting with the custom mandibular tray stabilizer and a titanium plate.

The fibular autograft was harvested with intact skin and vasculature[4] and guided by additional PLA cutting templates tailored to the defect geometry (Figure 5). These guides enabled precise segmentation of the fibula to ensure correct curvature and contact surfaces for mandibular reconstruction.[3] Titanium screws and plate were used to secure the graft. They were selected for their high strength-to-mass ratio, corrosion resistance, osteo-integration and long-term biocompatibility in load-bearing applications. Vascular anastomosis was performed between the facial and peroneal vessels to restore perfusion[5], and the wound was closed with preservation of the mental nerve and inferior labial artery (Figure 6).

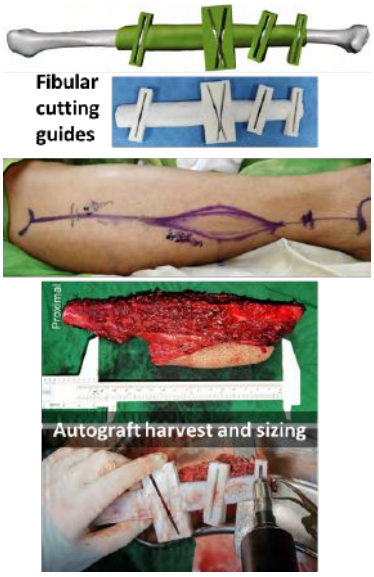


Figure 5. Preparation of the fibular autograft with intact skin and vasculature using 3D-printed surgical cutting guides.

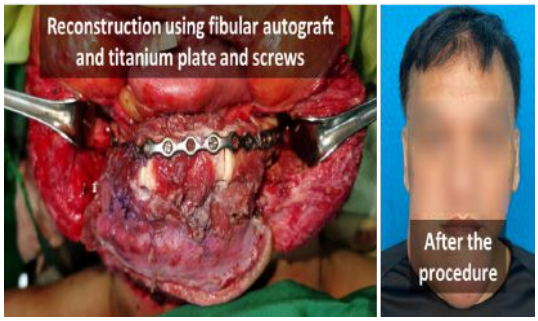


Figure 6. Reconstruction using the fibular autograft and titanium plate and screws.

This clinical case exemplifies the transformative application of 3D technologies in orthopaedic biomaterials-based reconstruction. The combination of 3D CT imaging, CAD modeling and 3D printing enabled a level of precision and personalization that significantly improved surgical outcomes. PLA (though not implanted) played a vital role in preoperative planning and intraoperative guidance. Titanium provided durable fixation and mechanical stability, while the autologous fibular graft functioned as a biologically active substrate capable of bone tissue remodeling and integration.

From a biomaterials perspective, this workflow reflects the evolving role of engineered materials in reconstructive surgery. The digital-to-physical pipeline (from imaging to printed guides) demonstrates how orthopaedic biomaterials can be customized to individual anatomy and clinical pathology. Moreover, the scalability of these approaches, particularly in resource-limited settings such as the Philippines, stresses the importance of accessible biomaterials innovation.

Looking ahead, the development of bioactive scaffolds, resorbable fixation systems and tissue-engineered bone substitutes will further enhance integration and reduce donor site morbidity. The scope of orthopaedic biomaterials has already expanded to include digitally planned, biologically integrated, and globally accessible solutions for addressing complex reconstructive challenges, as demonstrated in this presentation within the Society For Biomaterials (SFB).

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Member News

By Guillermo Antonio Ameer, ScD



Guillermo Ameer, ScD, Professor, Department of Biomedical Engineering, Department of Surgery, Northwestern University

A bone regeneration device using bioactive materials pioneered by Guillermo Ameer, the founding director of the Querrey Simpson Institute for Regenerative Engineering at Northwestern University (QSI RENU), was recently used in its first surgical case, Acuitive Technologies Inc. reported.

Called Citregraft, the technology is composed of the citrate-based polymers developed in the Ameer laboratory as well as bioactive glass. It is a highly porous, synthetic bone graft substitute that can be morselized to fit irregular defects. After placement in a bony void, Citregraft binds local growth factors and steadily releases citrate to support bone regeneration before resorbing and being replaced by the patient's natural bone.

In its first surgical use, the sponge-like material repaired bone tissue that was harvested as part of an ACL reconstruction on the knee. The device received FDA clearance in November 2024 and is one of several products in Acuitive Technologies' CITREGEN line.

Ameer has financial interests in Acuitive Technologies, Inc.



Bingyun Li, PhD, Professor, Department of Orthopaedics, West Virginia University

In recognition of his longstanding commitment to and excellence in orthopaedic research, Bingyun Li of the Department of Orthopaedics at West Virginia University was nominated, selected and inducted into the College of Fellows of the International Combined Orthopaedic Research Societies (ICORS) in October 2025. Also, in recognition of his dedication to trainees, Li was awarded the Chancellor's Mentor Award (Chancellor's Awards for Outstanding Achievements) from West Virginia University Health Sciences Center in August 2025.

Member News



Mohini Kamra, PhD, Assistant Professor, University of South Alabama

Mohini Kamra, PhD, Assistant Professor, University of South Alabama, Member of SFB since her postdoc days at the University of Texas at Austin. Kamra recently started her new role as faculty in the Department of Biomedical Sciences at University of South Alabama. She is excited to embark on this new journey as she establishes her research lab focused on developing biomaterials for targeted remediation of many of the concerns revolving around women's health. As the Vice Chair of SFB SIG, one of her main aims is to contribute to enhancing education and learning experiences centered around Biomaterials.



Leo Wang, MD, PhD, Assistant Professor of Dermatology and Bioengineering, University of Pennsylvania

Leo Wang, MD, PhD, Assistant Professor of Dermatology and Bioengineering, University of Pennsylvania, received the NIH DP5 Early Independence Award to develop a new biomaterial to treat human scars by regenerating hair follicles.



Bingyun Li and ICORS fellows from the U.S. and Canada attending the ICORS conference in Adelaide, Australia.

Industry News

By Subra Guna, PhD

INDUSTRY MARKET SIZE AND GROWTH

The biomaterial industry in the United States was valued at approximately $71.3 billion in 2025, with an expected compound annual growth rate (CAGR) of around 8 percent extending toward 2035. Another data point suggests a market size of about $34.7 billion in 2025 with an 11.12 percent CAGR projected through 2034, reflecting segment and source differences. Growth is propelled by increased demand in medical applications such as orthopedics, cardiovascular treatments, wound care, dental reconstruction and implantable devices.[1,2]

KEY APPLICATIONS AND INNOVATIONS

Major applications driving the industry include surgical implants, bioresorbable materials, drug-delivery systems and tissue engineering scaffolds. A strong trend toward 3D printing personalized biomaterials for implants and bio-based polymers aimed at sustainability are notable. Advanced formulations involving hydrogels, ceramics, polymer composites and bioactive materials are accelerating innovation and adoption in clinical settings.[1,3]

REGIONAL INDUSTRY HIGHLIGHTS

Prominent biomaterial industry hubs in the U.S. include California and Washington in the West, Texas and Florida in the South, Massachusetts and New York in the Northeast, and Illinois and Ohio in the Midwest. These clusters benefit from a high concentration of biomedical firms, research institutions and favorable regulatory environments that foster innovation and commercialization.[1]

CHALLENGES AND OPPORTUNITIES

While strong growth prospects exist, challenges such as high R&D expenses, regulatory compliance costs and the need for extensive clinical validation persist. Opportunities arise from increasing investments in regenerative medicine, bioactive material development and expanding public-private partnerships driving new product commercialization and market penetration.[1,2]

MARKET TRENDS AND FUTURE OUTLOOK

The biomaterial sector is advancing through disruptive technologies like medical 3D printing and sustainable biopolymers. Supportive regulatory changes and funding streams aimed at accelerating regenerative and personalized medicine further enhance market dynamics. Continued innovation in scaffold composites and hydrogel biomaterials is expected to sustain robust expansion and broader clinical use in the near future.[2,3]

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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!

Government News

FEDERAL APPROPRIATIONS UPDATE

Following the 43-day government shutdown, the longest in U.S. history, President Trump signed legislation that reopened the government and provided temporary funding for several federal agencies, alongside full-year appropriations for others. The legislation includes a Continuing Resolution (CR) that maintains funding at FY 2025 levels through Jan. 30, 2026. The CR covers Labor-HHS, which includes NIH, ARPA-H, CDC, BARDA and AHRQ; Defense, including the Congressionally Directed Medical Research Programs (CDMRP); and Commerce-Justice-Science, including NSF, among other key sectors such as Energy and Water, Homeland Security and Transportation-HUD. In addition, the legislation provided full-year funding for Agriculture-FDA, Military Construction-Veterans Affairs and the Legislative Branch. Notably, the measure extends the legislative prohibition on changes to indirect cost reimbursement at NIH, providing stability for institutions and federally funded research programs.

UPDATE TO NIH FUNDING POLICY

On Nov. 21, 2025, NIH announced that it is implementing a unified funding strategy intended to bring more consistency to award decisions across Institutes, Centers and Offices (ICOs), beginning with the January 2026 Council round. This action follows the NIH Director's August statement and represents a shift in how funding decisions will be structured and communicated.

According to NIH, the new framework reflects an effort to manage the complex factors that influence funding decisions, including peer review outcomes, public health priorities, scientific opportunities, investigator career stage, workforce considerations and available resources. The framework establishes a set of "core tenets" that all ICO funding policies are expected to follow, such as alignment with the NIH mission, use of full peer review information, consideration of a broad range of research topics, geographic and institutional funding balance and adherence to available budgets.

NIH is also consolidating information on ICO funding policies by creating a new section on the Grants & Funding website, where ICOs will centrally post their financial management plans and decision-making approaches.

A major change in this update is NIH's move away from the use of paylines. Previously, about half of ICOs used paylines to guide funding decisions, though NIH acknowledges the process was sometimes unclear to the research community. Under the new approach, paylines will no longer be used to develop pay plans; instead, peer review scores will be considered in combination with broader NIH and ICO priorities and budget constraints.

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