NSF I-CORPS: BOOSTING NEW TECH INTO THE MARKETPLACE

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2021 SFB ANNUAL BUSINESS MEETING

BIOMATERIALS FORUM

OFFICIAL NEWSLETTER OF THE SOCIETY FOR BIOMATERIALS

SECOND QUARTER 2021 • VOLUME 43, ISSUE 2

ALSO INSIDE

2021 SFB AWARD WINNERS

IN MEMORY OF JONATHAN BLACK, F.B.S.E. (1939-2020)

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BIOMATERIALS FORUM

The official news magazine of the **SOCIETY FOR BIOMATERIALS** • Volume 42, Issue 4

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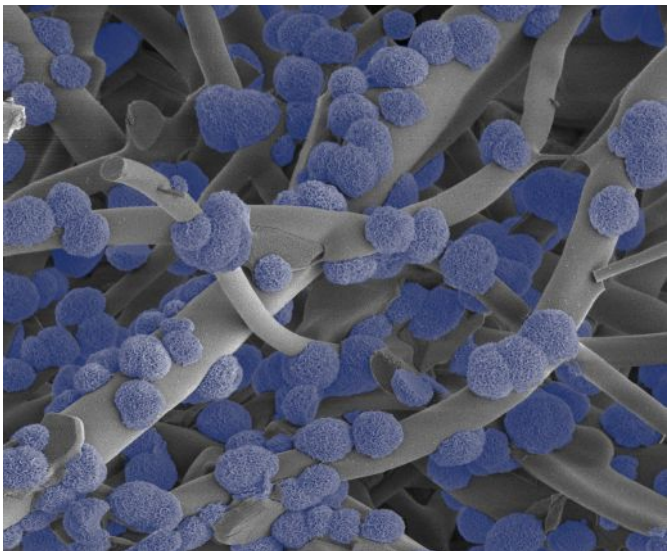

ON THE COVER

The cover image shows a biomineralized silica fiber matrix. This novel biomaterial platform is formed by sintering amorphous silica fibers that are bioactive and biodegradable.

Photo credit: Dr. Syam P. Nukavarapu of the University of Connecticut.

From the Editor

By Roger Narayan, Biomaterials Forum Executive Editor

It is my pleasure to share this issue of *Biomaterials Forum* with you. I want to congratulate Guillermo Ameer and Kris Kieswetter for the successful 2021 Annual Meeting, which brought together our community earlier this year to hear about biomedical materials research and celebrate the achievements of our colleagues. I also want to bring your attention to the upcoming Joint Symposium with the Japanese Society for Biomaterials January 8-10 in Honolulu — additional information on this event will appear in the next issue of the *Forum*.

One item in this issue of the *Forum* that I would like to bring to your attention is the announcement of the Society's new team of leadership volunteers, which is provided on Page 10. The Society and its membership are truly blessed to have the contributions from this group of distinguished biomaterials researchers.

This issue of the *Forum* brings news of the election of Professor Cato Laurencin to the National Academy of Sciences. Martine LaBerge reflects on the career of Professor Jonathan Black and Buddy Ratner considers the career of Don Lyman — two pioneers of our field.

This issue also includes a discussion of the National Science Foundation I-Corps program by Amy Parker and Wade Fulghum, two of my colleagues at North Carolina State University. I hope that you find this information helpful as you consider pathways to commercialize the innovations from your research. I hope to bring additional articles that describe federal funding opportunities that support the commercialization of biomedical materials research in future issues. I also would like to highlight the efforts of Candan Tamerler and Paulette Spencer to prevent tooth decay with antimicrobial peptides and the role of artificial intelligence in improving the design of these innovative materials.

We are always collecting ideas for upcoming issues of the *Forum*. Please do not hesitate to reach out — we look forward to sharing your stories and achievements!

Yours truly,
Roger Narayan

From the President

By Guigen Zhang, SFB President

I trust you all enjoyed the 2021 SFB Annual Meeting held virtually on April 20-23, 2021. Though we may feel fatigued with virtual meetings, from the conversations I had with some of the attendees during the meeting, I noted many positive feelings toward the enhanced virtual experience. Many thanks to our program Co-Chairs, Kris and Guillermo, the Program Committee, and Dan and Shena at AH. *We also want to hear from all attendees: please take a few minutes to complete the post-meeting survey to share with us your experiences and your suggestions for improvements.*

I kick off my term as the SFB President with the deepest honor and gratitude for the confidence you placed in me. Growing up professionally in this Society, from the earlier days as a graduate student up until today, I am proud to call SFB home. Here I found, and am still finding, mentorship, friendship and collaborations in steering my career. The abundant kindness and caring I have witnessed and received in the SFB community over the years have instilled in me a sense of a reciprocal responsibility. I look forward to working together with you all in the coming year to advance the SFB's mission and elevate the SFB to a new high.

We will continue to celebrate scientific excellence in recognizing our deserving members with various prestigious SFB awards. So, I ask each of you to help the 2021 Awards and Nomination Committee identify and recognize these high achieving members among us.

We will also do the following: *pursue scientific excellence and inclusion, enhance the viability of SFB and expand SFB's visibility and global reach.*

On Pursuing Scientific Excellence and Inclusion, it is time for us to elevate our commitment to inclusion from the perspective of scientific excellence. Typically, when we talk about inclusion, we often think of playing a fair game or equal opportunity. In fact, it is more about if we can do the science right. Take the Pulse Oximeters as an example: these devices are known to give higher oxygen readings in people with darker skin when triaging COVID-19 patients, leading to missed opportunities to provide timely treatments to these patients, which in turn would keep the virus spreading in the community and cause more deaths. This is not scientific excellence! We will charge our newly formed Diversity, Equity and Inclusion Committee to identify ways to help us elevate our understanding so that we can celebrate inclusion and scientific excellence in the spirit of convergence. Furthermore, in living through the sadness of social injustice and hatred lately, I sense strongly our obligation to do more to help celebrate racial diversity and embrace cultural differences beyond the SFB community in each of our own institutions, workplaces and communities.

On Enhancing the Viability of SFB, one of our uttermost challenges is to grow our membership. We will expand our efforts to groom trainees and students because they are the *life and blood of our Society*. Furthermore, we need to develop new strategies to bring back government and industry partners. To do so, we will listen to their needs and identify ways to work together. Particularly, I would work with colleagues at the FDA to explore how we can work together to better integrate translational science with regulatory science, alter the sequence of regulatory involvement in the lifecycle of medical technology translation, develop relevant educational programs and build more effective university, government and industry partnerships, among others.

On Expanding SFB's Visibility and Global Reach, we must remain relevant beyond our own scientific community. We will work with advocacy groups, particularly the Government-University-Industry Research Roundtable, the American Institute of Medical and Biological Engineering, etc. to play a more participatory role to inform better policies on biomedical research, technology innovation, and education.

We will reach out soon to seek your input and wisdom through surveys and other exchanges. *Specifically, we will conduct a general member survey as well as a council survey on Foresight Initiatives to guide us on relevant initiatives to take on in the coming years.*

Finally, I would ask you to hold your calendar for the Joint Symposium planned for January 8-10, 2022 to honor the seminal contributions of four biomaterials pioneers: James Anderson, Art Coury, Tadashi Kokubo and Teruo Okano. Also, it is time for us to plan for the 2022 SFB Meeting, so please do not hesitate to share your ideas with the Program Committee of the 2022 Annual Meeting when the call for ideas and proposals comes out.

Thank you again for your devotions and contributions to the SFB!

Best wishes,
Guigen Zhang
SFB President, 2021-2022

The following professionals are recognized for their outstanding achievements in and contributions to the biomaterials field. Each award recipient was honored during the Opening Ceremony at this year's Society for Biomaterials 2021 Virtual Annual Meeting and Exposition on Wednesday, April 21, 2021.

View the full press release at: biomaterials.org/publications/news/sfbs-2021-award-recipients.

Founders Award: *William R. Wagner, PhD, University of Pittsburgh*

C. William Hall Award: *SuPing Lyu, PhD, Medtronic*

Society For Biomaterials Award for Service: *Liisa Kuhn, PhD, UConn Health*

Technology Innovation and Development Award: Lonnie Shea (University of Michigan), Stephen Miller (Northwestern University), John Puisis, Jim Herrmann, Cour Pharmaceutical

Clemson Award for Applied Research: *Karen Christman, PhD, University of California, San Diego*

Clemson Award for Basic Research: *Brendan Harley, PhD, University of Illinois at Urbana-Champaign*

Clemson Award for Contributions to the Literature: *Guillermo Ameer, ScD, Northwestern University*

Mid-Career Award: *Sarah Stabenfeldt, PhD, Arizona State University*

Young Investigators Award: *Nasim Annabi, PhD, University of California, Los Angeles*

Student Awards for Outstanding Research, PhD Candidate Category:

- *Marian Ackun-Farmmer, University of Rochester*
- *Taneidra Buie, University of Texas at Austin*
- *Zoe Lynn Harrison, University of Memphis*

C. William Hall Scholarship: *Kaylee Bundy, Mississippi State University*

Cato T. Laurencin Travel Fellowship:

- *Breajah Tyson, University of Connecticut*
- *Sophia Saenz, University of Florida*

To learn more about each award, please visit: biomaterials.org/awards.

Member News

By Joyce Wong, Member-at-Large

Thank you everyone who submitted their news this past quarter! This is my last *Forum* submission as Member-at-Large, and as promised, this issue includes recent patents collected from our members. Please note that this is not a complete list but is what was received. It has been a pleasure to serve as your Member-at-Large.

Remember to continue tagging SFB in your posts on Twitter (@SFBiomaterials), Facebook, and LinkedIn!

SFB MEMBER NEWS AND ACCOMPLISHMENTS FROM THE PAST QUARTER

Jessica Larsen, Assistant Professor, Clemson University, Department of Chemical and Biomolecular Engineering, Department of Bioengineering, recently received a NSF CAREER Award entitled, "CAREER: Diagnosing the Undiagnosable: Using Enzyme Upregulation to Probe Cellular Behavior in Neuropathic Lysosomal Storage Disease" from CBET, specifically Engineering of Biomedical Systems. This major award supports research of interactive biomaterials that have the potential to provide diagnostic information in real time in the brains of patients with neurodegenerative disease, GM1 Gangliosidosis.

Cato T. Laurencin, Albert and Wilda Van Dusen Distinguished Professor of Orthopaedic Surgery and Chemical, Materials and Biomedical Engineering at the University of Connecticut School of Medicine, CEO, The Connecticut Convergence Institute for Translation in Regenerative Engineering, has been named the 2021 Kappa Delta Ann Doner Vaughn Award recipient for his 30 years of scientific breakthroughs in musculoskeletal regenerative engineering, the field which he founded and brought to the forefront of translational medicine.

On April 26, 2021, the National Academy of Sciences announced that Dr. Laurencin had been elected to the National Academy of Sciences. Please see the article on page 9 for details!

Syam Nukavarapu, Associate Professor, University of Connecticut, and Biomedical Engineering, was recently awarded an NIH R01 from the National Institute of Biomedical Imaging and Bioengineering (NIBIB) to engineer and study bone-cartilage interface. The goal of this project is to implement geometric and physical cues in a three-dimensional setting to design synthetic grafts for complex tissue engineering. This project will push the frontier of tissue engineering by developing new image modalities to correlate biomaterial stiffness and geometry with regenerated tissue quality and its function. These efforts will utilize additive manufacturing methods to create scaffold structures with precise microstructure, stiffness and environment.

Nicholas A Peppas, the Cockrell Family Regents Chair in Engineering and Professor of Chemical Engineering, Biomedical Engineering, Pediatrics, Surgery, and Pharmaceutics at The University of Texas at Austin, recently received the American Chemical Society Oesper Award, which recognizes an outstanding chemist for a lifetime of significant accomplishments in the field of chemistry with long lasting impact on the chemical sciences. This award recognizes his work in biomaterials, drug delivery, bionanotechnology and nanomaterials, which blends modern molecular and cellular biology with engineering principles in order to design the next generation of therapeutic agent release systems for diabetes, autoimmune and cardiovascular disease treatment.

Dr. Peppas was also recently elected and inducted as a member of the Indian National Academy of Engineering.

Christine Schmidt, Professor and Chair, Biomedical Engineering, University of Florida, was elected to the Academy of Science, Engineering and Medicine of Florida (ASEMFL). What the National Academy of Science, Engineering and Medicine is to the nation, ASEMFL is for the State of Florida. Dr. Schmidt has been elected to ASEMFL for "Innovation of biomedical technologies impacting thousands, and university and national biomedical engineering leadership." The induction will take place during the Annual Meeting of the Academy in Orlando on November 6, 2021.

Sarah Stabenfeldt, Associate Professor, Biomedical Engineering, Arizona State University and **Rachael Sirianni**, Associate Professor, Vivian L. Smith Department of Neurosurgery McGovern Medical School/University of Texas Health Science Center at Houston, received an award for their work, "NIH R01 - R01 NS116657: Exploiting Sex-Dependent Brain Injury Response for Nanoparticle Therapeutics" — an MPI effort led by Stabenfeldt and Sirianni. A brief write-up from ASU about the work can be found on the engineering page at asu.edu.

Marissa Wechsler, Assistant Professor, Department of Biomedical Engineering and Chemical Engineering, The University of Texas, San Antonio, recently (in January 2021) started as an Assistant Professor in the Department of Biomedical Engineering and Chemical

Member News (continued)

Engineering at the University of Texas at San Antonio. Her research utilizes engineered polymeric systems for biomarker detection, drug delivery and the design of complex biological microenvironments with applications in nanotechnology, biosensing and tissue engineering.

Dr. Wechsler conducted her dissertation research with Dr. Nicholas Peppas on the use of "Recognitive Hydrogel Coated Gold Nanoshells for Label-Free Detection of Tear Biomarkers," and graduated with her PhD in Biomedical Engineering from the University of Texas at Austin in December 2019. She then conducted post-doctoral research training with Dr. Kristi Anseth at the University of Colorado at Boulder.

Jennifer West, Dean of Engineering and Applied Sciences, University of Virginia will be the Dean of Engineering and Applied Sciences at the University of Virginia starting July 1, 2021. A brief write up can be found on the UVA Today site.

RECENT PATENTS AWARDED

Ngan Huang, Assistant Professor, Department of Cardiothoracic Surgery, Stanford University.

1. **Huang NF**, Zaitseva T, Paukshto M, et al. A graft for directed vascular and lymphatic regeneration and methods to guide endothelial cell assembly. Fibralign Corporation and the Board of Trustees of Leland Stanford Junior University. Patent# US 10,238,769B2. 2019.
2. Hong G, Lee J, **Huang NF**, et al. Vascular imaging using near infrared fluorescence. The Board of Trustees of Leland Stanford Junior University. Patent # US 10,264,974. 2019.

Adam E. Jakus, Co-Founder and Chief Technology Officer, Dimension Inx.

Dimension Inx announces an issuance of US Patent for Biomaterials Design and 3D-Printing Manufacturing System. The biofabrication company expands its patent portfolio with a seminal patent protecting its 3D-Painting System and proprietary bioinks for organ and tissue repair and regeneration.

David Kohn, Natalie C. Roberts Endowed Professor, University of Michigan, Departments of Biologic and Materials Sciences, and Biomedical Engineering.

1. Mineralization and biological modification of biomaterial surfaces, US Patent # 9,072,813. 2015.
2. Mineralization and biological modification of biomaterial surfaces, US Patent # 9,480,773. 2016.
3. Rapid vascularization of bioengineered tissues, US Patent Application # 15/333,935.

Syam Nukavarapu, Associate Professor, Biomedical Engineering, University of Connecticut.

1. Gradient porous scaffolds, US Patent # 9,707,322 B2. 2017.

Nicholas A Peppas, the Cockrell Family Regents Chair in Engineering and Professor of Chemical Engineering, Biomedical Engineering, Pediatrics, Surgery, and Pharmaceutics at The University of Texas at Austin.

1. **Peppas NA,** William Liechty. Delivery of small interfering rna and micro rna through nanogels containing hydrophobic pseudo-peptides, US Patent 11,000,602. May 11, 2021.
2. Knipe JM, Strong LE, **Peppas NA**. Hydrogels for delivery of therapeutic compounds, US Patent 10,835,609. November 17, 2020.
3. Koetting M, **Peppas NA.** Polymers for delivery of therapeutic proteins, US Patent 10,500,256. December 10, 2019.
4. Horava SD, **Peppas NA.** Polymers for delivery of Factor VIII and/or Factor IX, US Patent 10,265,405. April 23, 2019.
5. **Peppas NA,**i Culver H. Method of preparation of biodegradable nanoparticles with recognition characteristics, US Patent 10,086,091. October 2, 2018.

Ryan K Roeder, Professor, University of Notre Dame, Bioengineering Graduate Program, Department of Aerospace and Mechanical Engineering.

1. **Roeder RK**, Converse GL, Smith SM. Porous composite biomaterials and related methods, U.S. Patent Application Number. 2014/0236299. August 21, 2014. Recently received allowance.
2. **Roeder RK,** Meagher MJ, Kane RJ. Tissue scaffolds having bone growth factors, U.S. Patent Number 9,550,012. January 24, 2017.

Anita Shukla, Assistant Professor of Engineering, Brown University, School of Engineering.

1. **Shukla A**, Shukla S. Tunable anti-microbial loaded hydrogels, U.S. Patent Number 10, 058, 506 B2. August 28, 2018.

Joyce Y. Wong, Professor of Biomedical Engineering and Materials Science and Engineering, Boston University.

1. Zhong, **Wong JY.** Compositions and methods for isolating and enriching IgM-producing cells and uses thereof, U.S. Patent No. 10,842,816.: November 24, 2020.
2. **Wong JY**, Whitaker RD, Ruiz-Opazo N,. Herrera VLM. Theranostic compositions and uses thereof, U.S. Patent No. 10,568,970. February 25, 2020.
3. Kim J , **Wong JY.** Multi-layered cell constructs and methods of use and production using enzymatically degradable natural polymers, U.S. Patent No. 10,256,582 B2. January 7, 2020.

Professor Cato T. Laurencin Elected to the National Academy of Sciences

On April 26, 2021, the National Academy of Sciences announced that Dr. Cato T. Laurencin, a distinguished member of the Society For Biomaterials, was elected as a new member — making him the the first surgeon in history to be elected to the National Academy of Engineering, the National Academy of Medicine, the National Academy of Sciences and the National Academy of Inventors.

Dr. Laurencin is known as a world leader in biomaterials, polymeric materials science, nanotechnology, stem cell science, drug delivery systems and a field he has pioneered, regenerative engineering. His breakthrough achievements in science, engineering and medicine have resulted in transformative advances in improving human life. Laurencin's papers and patents have had broad impact on human health, including pioneering the use of nanotechnology in musculoskeletal regeneration and ushering in a new era in orthopaedic therapies. For this work, Dr. Laurencin received the National Medal of Technology and Innovation, the highest honor bestowed in America for technological achievement, from President Barack Obama.

Laurencin has also pioneered work in the development of systems for soft tissue regeneration. He invented the Laurencin-Cooper ligament (LC ligament) for ACL regeneration, and engineered grafts for shoulder rotator cuff tendon repair and regeneration. National Geographic Magazine featured the LC Ligament as part of its "100 Scientific Discoveries that Changed the World" edition. Dr. Laurencin received the Philip Hauge Abelson Prize from the American Association for the Advancement of Science (AAAS) "for signal contributions to the advancement of science in the United States." He is the first person in history to receive both the oldest and highest award of the National Academy of Medicine (the Walsh McDermott Medal) and the oldest and highest award of the National Academy of Engineering (the Simon Ramo Founders Award).

A role model in science and champion of social justice, Laurencin has two awards named in his honor. The Society for Biomaterials established The Cato T. Laurencin, MD, PhD Travel Fellowship, which is given at its opening ceremonies. In addition, The W. Montague Cobb/NMA Health Institute and the National Medical Association (NMA) established the Cato T. Laurencin Lifetime Research Achievement Award, given during the opening ceremonies of the NMA Meeting. He received the 2020 Herbert W. Nickens Award from the AAMC for work in promoting justice, equity and fairness.

Dr. Laurencin is the Albert and Wilda Van Dusen Distinguished Endowed Professor of Orthopaedic Surgery and Chief Executive Officer of the Connecticut Convergence Institute for Translation in Regenerative Engineering. He is a University Professor at UConn, the school's highest academic rank. He is a fellow of the American Academy of Orthopaedic Surgeons and an elected member of the American Surgical Association. He has been named to the list of America's Top Doctors for the past 15 consecutive years.

Dr. Laurencin received his BSE in chemical engineering from Princeton University, his MD, magna cum laude, from the Harvard Medical School, and his PhD in biochemical engineering/ biotechnology from the Massachusetts Institute of Technology where he was named a Hugh Hampton Young Fellow.

Staff Updates

By Shena Seppanen, Assistant Executive Director

Hello from Society For Biomaterials Headquarters! Our thanks and appreciation to all those who joined us for the 2021 Virtual Annual Meeting & Exposition! With the beginning of a new program year, the Society's Board of Directors, Governing Council, Committees and Special Interest Groups (SIGs) will continue the work of advancing the Society's mission. We also extend a warm welcome to our new leadership volunteers, as listed below.

ANNUAL BUSINESS MEETING

The Society's Annual Business meeting took place virtually on Thursday, April 22, 2021. Results of the spring election were announced, and the following people have been elected as officers for the SFB Board of Directors:

2021-2022 President-Elect: Elizabeth Cosgriff-Hernandez, PhD, University of Texas at Austin

2021-2022 Secretary-Treasurer-Elect: Danielle Benoit, PhD, University of Rochester

2021-2022 Member At-Large: John Fisher, PhD, University of Maryland

2021-2022 SIG Chair Representative: Ashley Carson Brown, PhD, NC State University/UNC-Chapel Hill

Election of 2021-2022 Awards, Ceremonies and Nominations Committee: The following were elected by the members present: Brendan Harley, ScD, Joyce Wong, PhD, L.D. Timmie Topoleski, PhD and Rena Bizios, PhD

New Council – The following members will comprise the 2021-2022 Council, serving alongside the elected Board as Committee Chairs:

Awards, Ceremonies, and Nominations	Andrés J. García, PhD
Bylaws	LaShan Simpson, PhD, Mississippi State University
Diversity, Equity, and Inclusion	Edward A. Botchwey, PhD
Education and Professional Development	Thomas Dziubla, PhD
Finance	Danielle Benoit, PhD
Industrial Affairs (f/k/a - Devices and Materials)	SuPing Lyu, PhD
Liaison	Bingyun Li, PhD
Membership	Natalie Artzi, PhD
Presidents Advisory	Shelly Sakiyama-Elbert, PhD
Program Co-Chairs	Carl Simon, PhD, NIST and Cherie Stabler, PhD, University of Florida
Publications	Jan Stegemann, PhD
Student Chapter President	Deanna Bousalis (term ends July 2021)

If you have any questions, require any information, or have suggestions for improved services, please contact the Society's Headquarters office:

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Student Chapter News

By Deanna Bousalis, National Student Chapter President

Greetings, SFB Members!

We hope you all enjoyed the Annual Meeting programming that was organized by the National Student Section. It was wonderful to meet and interact with our student members during the networking sessions and Student Chapter meeting.

This year, we co-organized many events with the SFB Young Scientist Group! On the first day of the conference, we held the "If I Were A Student Now" workshop, with panelists Dr. Gordana Vunjak-Novakovic, Dr. Buddy Ratner, Dr. Neal Vail and Ann Beal Salamone. The next day, we hosted the "Translating Technology from Bench to Market" panel with participants Drs. Larry Thatcher, Sarah Mayes, Johnny Lam, Jordan Miller and Michaela McCrary. The student section also organized a student luncheon focused on tips for writing successful fellowship applications. Our panelists included Dr. Leslie Frieden, Dr. Shannon Brown and Nicholas Fischer. Through these events, we hope we were able to inspire students, provide them with helpful information for success and perhaps guide them in their career decisions.

We made SFB history this year by organizing an inaugural "3-Minute Thesis" competition! We had more applicants than we ever anticipated, so we had to pre-screen abstract submissions.

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NSF I-Corps Sites Bolster Commercialization of University Research

By Amy Parker and Wade Fulghum

The National Science Foundation (NSF) is one of the largest federal funding agencies for the development of innovative university research in the United States. By providing a funding mechanism for early stage technologies that still require proof of technical feasibility before becoming marketplace-ready (as is the case with many technologies developed in the university setting), NSF plays a critical role in the advancement of new solutions into the marketplace where they can benefit society as a whole. Its Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) grants in particular are key in funding innovative but technically risky solutions that startups are working to commercialize, awarding $200 million in non-dilutive funding to small businesses each year.

Unfortunately, a large portion of research-based startup companies will fail to be successful in commercializing their technology. One weakness among many new entrepreneurs is a lack of understanding about real marketplace problems and needs that can affect the adoption of new technologies, leading to the development of a solution that no one wants. This can be especially true for university spinouts being led by university faculty and students who may have little to no business experience. NSF recognized this challenge and partnered with entrepreneur and Stanford professor Steve Blank in 2011 to create the Innovation Corps (I-Corps) curriculum. The NSF I-Corps Program provides customer discovery and market research training for university faculty and students seeking to commercialize their discoveries to help them better their understanding of marketplace needs and increase the chances of their inventions making it from the lab to the marketplace. The curriculum challenges teams to get out into the marketplace and talk with real-world customers to understand their decision-making processes and the requirements for the adoption of new technologies. This customer discovery work is critical and forms the foundation for the development of a viable business model that will improve a venture's odds of success.

While the curriculum was originally developed and launched in 2011, several different delivery methods exist today. The NSF I-Corps Teams Program is the most intensive option available for university startups and research teams. Teams that are accepted to this national program receive $50,000 in funding to complete at least 100 interviews with potential customers and industry partners of their technologies over the course of seven weeks. Participation also includes three in-person training sessions at one of the nine I-Corps Nodes located across the country. The ultimate goal is for teams to reach a "go" or "no-go" decision by the end of the seven-week course as to whether to continue pursuing commercialization of their technology. This enables teams to determine in a relatively short period of time if it is feasible to continue commercialization efforts without sinking a large amount of money and time into the development of a technology that the marketplace may not adopt.

"ONE WEAKNESS AMONG MANY NEW ENTREPRENEURS IS A LACK OF UNDERSTANDING ABOUT REAL MARKETPLACE PROBLEMS AND NEEDS THAT CAN AFFECT THE ADOPTION OF NEW TECHNOLOGIES, LEADING TO THE DEVELOPMENT OF A SOLUTION THAT NO ONE WANTS."

For many faculty and students, devoting seven weeks to customer discovery along with typical day-to-day responsibilities at the university can be a significant barrier to participation in the National Teams Program. NSF recognized this challenge and created I-Corps "Sites" to better serve research teams that have an interest in learning the I-Corps methodology but are not yet ready to commit to the Teams Program. Sites are typically located at universities and managed by a research commercialization office, and serve as an initial entry point for potential teams into NSF's National Innovation Network (NIN). Sites provide introductory courses to the customer discovery process and also provide access to other training and resources to assist in technology commercialization. Site programs have flexibility in how the curriculum is delivered so the length of an I-Corps course can vary by institution, with some universities offering a two-day, short course and others offering a ten-week or semester-long course. While I-Corps instructors play a key role in helping teams understand and develop an interview strategy, the real learning occurs through interviews with potential customers. Teams are tasked with completing a smaller number of interviews than the 100 required by the National Teams program, typically twenty to thirty depending on the Site. Although twenty interviews can be considered a small sample size, it is typically enough for teams to become more comfortable cold calling and talking to potential customers and industry partners, and can provide data points on the direction in which teams should focus their future customer discovery efforts.

Sites can also assist in matching participating teams with qualified

NSF I-Corps Sites Bolster Commercialization of University Research (continued)

industry mentors to help them navigate their target market ecosystem. The typical team is composed of a faculty member, a graduate student or postdoc working in the faculty's research program, and a mentor with industry or business experience. Teams that apply may not have a business mentor and a Site program will often work to match teams with a qualified mentor through its local entrepreneurial ecosystem. University teams that complete a regional Site Program are then eligible to apply for the more intensive National Teams Program, which is only open to teams that can claim NSF funding lineage or NSF I-Corps Site participation, to build on the work they started in the Site course. Completion of the Teams Program qualifies teams to apply to NSF's Partnerships for Innovation (PFI) grant for prototype development and also greatly increases the competitiveness of future SBIR/STTR proposals. For university researchers that are seeking to assess and strengthen the commercial potential of technologies developed in their labs, I-Corps Sites serve as an introduction to the customer discovery process and an entry point into the larger NSF support network.

Find an I-Corps Site near you

Student Chapter News (continued)

During the competition, we played 16 pre-recorded student presentations while our judges, Drs. Jason Burdick, Jennifer Elisseeff and Nicholas Peppas, rated them based on various criteria. Congratulations to our winners Nada Haq-Siddiqi (1st place), Jenna Sumey (2nd) and Claire Tomaszewski (3rd). Thank you to our competition sponsor, Royal Society of Chemistry *Journal of Materials Chemistry B*, *Biomaterials Science* and *Materials Advances*, for graciously providing cash prizes for this event! We hope to make the 3MT Competition an annual occurrence.

This summer, we will be holding elections to determine the National Student Section's next President-Elect, Secretary/Treasurer-Elect and Bylaws Chair. If you are a student and you are reading this, please consider running for a position. As is evident from the many panels we organized this year, serving as an officer is a great way to expand your professional network and make connections with people you normally would not interact with. More information will be sent in upcoming emails.

In the meantime, please connect with us on Twitter at @sfb_students and email dbousalis@ufl.edu if you have any questions.

CALLING ALL BOOKWORMS!

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Scientists Drill Down on Bacteria-Fighting Fillings

ARTIFICIAL INTELLIGENCE AIDS DESIGN OF ANTIMICROBIAL DENTAL ADHESIVE

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Candan Tamerler: Photo Credit: University of Kansas

Paulette Spencer: Photo Credit: University of Missouri-Kansas City School of Dentistry

Ever had a cavity filled? Most of us know the drill. What you may not know, however, is that many of the fillings commonly used today last only about five to 10 years before they need to be replaced, often because of new cavities that crop up around the edges of the filling. This happens in part because the glue-like adhesive that seals the filling to the tooth breaks down over time, leaving tiny gaps into which cavity-causing bacteria can slip. Aided by artificial intelligence (AI), a cross-disciplinary team of experts in materials science and data science set out to tackle this problem by designing a dental adhesive with bacteria-fighting properties. The study, supported by NIDCR, recently appeared on the cover of *ACS Applied Polymer Materials*.1

Led by Candan Tamerler, PhD, and Paulette Spencer, DDS, PhD, both professors of bioengineering and mechanical engineering at the University of Kansas, the researchers looked to nature for an antibacterial solution. They landed on a class of molecules called antimicrobial peptides, which all organisms produce as a first line of defense against harmful bacteria.

The scientists modified these peptides by adding chemical "spacers"— short strings of amino acids — which, in turn, linked the peptides to methacrylate, a common ingredient in dental adhesives. The spacers were designed to keep the antimicrobial peptide firmly attached to the methacrylate, yet distanced enough to keep the peptide's structure and its bacteria-killing abilities intact. The researchers designed and tested two versions of peptide-laden adhesives—one with a short spacer and another longer one.

LED BY CANDAN TAMERLER, PHD, AND PAULETTE SPENCER, DDS, PHD, BOTH PROFESSORS OF BIOENGINEERING AND MECHANICAL ENGINEERING AT THE UNIVERSITY OF KANSAS, THE RESEARCHERS LOOKED TO NATURE FOR AN ANTIBACTERIAL SOLUTION.

In lab experiments, adhesives with the shorter spacer more effectively killed *Streptococcus mutans*, the bacterial species primarily responsible for tooth decay. To better understand this result, the scientists used AI-based computing to characterize the effect of varying spacer lengths on the structure and flexibility of antimicrobial peptides. The analyses showed that peptides with the shorter spacer maintained a more natural shape, which explained their superior antimicrobial activity.

"With these AI-based analyses, we can predict material designs that optimize a peptide's biological activity," says Tamerler.

The approach could be used to develop a variety of dental and medical materials that incorporate peptides and other biologically active molecules. Tamerler adds, "Using AI for rational, iterative design of materials could revolutionize the field of dentistry."

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Industry News

By Gopinath Mani, Industry News Editor

Pixee Medical, a company that develops digitally augmented surgery technology, announced that its **Knee+** AR computer-assisted orthopedic solution has received 510(k) clearance from the U.S. Food and Drug Administration.[1] Knee+ is a platform designed to assist orthopedic surgeons to perform surgeries better and faster by providing real-time positioning of instruments, right in their field of view.[1] Knee+ consists of a proprietary software using unique computer vision and artificial intelligence algorithms.[1] Knee+ requires minimal training since it does not change the overall technique for 90 percent of surgeons who use a conventional technique but have never utilized navigation or robots.[1]

Smiths Medical, a medical device manufacturer, recently announced the launch of the **Acapella® Choice Blue Vibratory Positive Expiratory Pressure (PEP) Therapy System**.[2] Acapella® is designed to aid in the removal of secretions for patients who have cystic fibrosis, chronic obstructive pulmonary disease (COPD), asthma, lung disease with secretory problems and patients with atelectasis.[2] The vibratory PEP therapy is a drug-free supplemental treatment that can reduce COPD flare-ups and hospital length of stay by 1.5 days.[2] The Acapella® Choice Blue System[2] is designed to: (a) effectively deliver medication when combined with a nebulizer; (b) achieve PEP in any position, whether sitting, standing, lying down or Trendelenburg; (c) Allow patients to easily adjust the resistance level to meet their therapeutic needs; (d) be disassembled for easy cleaning and disinfection in a variety of ways, including in the dishwasher. [2]

Orthofix Medical Inc., a medical device company with a spine and extremities focus, recently announced the U.S. Food and Drug Administration 510(k) clearance and first patient implant of the **FORZA™ Ti TLIF Spacer System.**[3] This implant was developed to help optimize Transforaminal Lumbar Interbody Fusion (TLIF) procedures.[3] The FORZA Ti Spacer with Nanovate™ Technology is a titanium 3D-printed interbody featuring an optimized design, porosity and surface that allows bone to grow into and through the spacer.[3] Interbody implants are spacers that surgeons insert between the vertebrae during spinal fusion surgery to help relieve pressure on nerves and hold the vertebrae in place while fusion occurs.[3] Some of the important features of this system[3] includes (a) 3D-printed porous titanium with macro, micro and nanoscale surface features; (b) nanoscale surface that has been shown to increase proliferation and alkaline phosphatase activity in human stem cells in vitro; (c) endplates with 400 micron pores and 50-percent porosity designed to help facilitate bone ingrowth; (d) functional gradient porous structure with 80-percent porosity at the midline of the implant which allows for increased fluoroscopic visualization; (e) large open graft window for packing bone-grafting material; (f) bulleted nose to assist with distraction; (g) straightforward instrumentation for easy implantation. [3]

MediPines AGM100™, a non-invasive pulmonary gas exchange analyzer, was selected as a finalist in the "Testing and Diagnostic Products and Systems" category in 2021 Medical Design Excellence Awards (MDEA).[4] The MDEAs is the premier design competition in the MedTech industry organized by Medical Device and Diagnostic Industry (MD+DI) and recognizes the significant achievements in medical product design and engineering that improve the quality of healthcare delivery and accessibility.[4] The MediPines AGM100 is the world's first portable non-invasive gas exchange analyzer. It enables rapid detection of the respiratory status of a patient and provides a comprehensive panel of twelve respiratory measurements including blood oxygen levels, oxygen deficit (A-a gradient), P/F ratio and alveolar oxygen and carbon dioxide levels.[4] Much of the innovation is related to the ease-of-information rather than having to draw a patient›s blood.[4] This portable point-of-care device simply uses a 90-second patient breath sample (the device works with any patient simply breathing normally).[4] This innovation has already led to improved patient outcomes at the hospitals where it has been adopted, especially those focusing on the impact from COVID-19 or pre-existing respiratory diseases.[4]

Johnson & Johnson Vision recently announced the FDA 510(k) clearance and CE mark of its next-generation phacoemulsification innovation, the **VERITAS™ Vision System**.[5] More than 90% of people develop cataracts by age 65, and cataract surgery is one of the most common outpatient procedures performed today with a success rate of approximately 98%.[5] Phacoemulsification is the most common cataract surgery technique performed and allows ophthalmologists to effectively emulsify and efficiently remove the eye›s internal lens when it has become cloudy from cataracts.[5] It is a delicate procedure that requires significant effort and control during surgery.[5] The high-performance phacoemulsification system developed by Johnson & Johnson Vision features technologies that allow surgeons to guide through any lens density with less surge and more stability.[5] The new system also provides advancements in ergonomics to further enhance usability during cataract surgery.[5]

The U.S. Food and Drug Administration authorized marketing of the **GI Genius**, the first device that uses artificial intelligence (AI) based on machine learning to assist clinicians in detecting lesions (such as polyps or suspected tumors) in the colon in real time during a colonoscopy.[6] According to the National Institutes of Health, colorectal cancer is the third leading cause of death

Industry News (continued)

from cancer in the United States.[6] Colorectal cancer usually starts from polyps or other precancerous growths in the rectum or the colon (large intestine).[6] As part of a colorectal cancer screening and surveillance plan, clinicians perform colonoscopies to detect changes or abnormalities in the lining of the colon and rectum.[6] A colonoscopy involves threading an endoscope (thin, flexible tube with a camera at the end), through the rectum and throughout the entire length of the colon, allowing a clinician to see signs of cancer or precancerous lesions.[6] The GI Genius is composed of hardware and software designed to highlight portions of the colon where the device detects a potential lesion.[6] The software uses artificial intelligence algorithm techniques to identify regions of interest.[6] During a colonoscopy, the GI Genius system generates markers, which look like green squares and are accompanied by a short, low-volume sound, and superimposes them on the video from the endoscope camera when it identifies a potential lesion.[6] These signs signal to the clinician that further assessment may be needed, such as a closer visual inspection, tissue sampling, testing or removal, or ablation of (burning) the lesion.[6] The GI Genius is designed to be compatible with many FDA-cleared standard video endoscopy systems.[6]

Rapid Medical, a company that develops responsive, adjustable neurovascular devices, recently announced the FDA clearance of its **TIGERTRIEVER™** revascularization device for use in the treatment of ischemic stroke.[7] TIGERTRIEVER is the first stent retriever to offer intelligent control, enabling neuro interventionalists to better remove blood clots and restore blood flow to the brain following an ischemic event — a condition that devastates 800,000 Americans annually.[7] Existing stent retrievers are non-adjustable, passive devices, delivered to the occlusion minimally invasively through the vasculature.[7] When unconfined, they slowly expand into the blood clot.[7] The blockage is hopefully captured and removed as the device is retrieved. Though currently recognized as the gold standard in treating large vessel ischemic stroke, traditional stent retrievers have significant limitations.[7] They cannot be adjusted for patient variability and fail in about 30% of revascularization procedures.[7] TIGERTRIEVER provides physicians with intelligent control during thrombectomy procedures.[7] With full device visibility and adjustability, physicians adapt their approach to visual and tactile feedback as needed.[7] The benefit of this tailored approach to ischemic stroke patients was proven in the recently published TIGER Trial.[7]

Contego Medical, Inc., a company that develops cardiovascular devices, recently announced the receipt of CE Mark approval for the **Neuroguard IEP® 3-in-1 Carotid Stent and Post-Dilation Balloon System with Integrated Embolic Protection (Neuroguard IEP System).**[8] The patented Neuroguard IEP System contains a novel, next-generation nitinol stent, a pre-positioned post-dilation balloon and an integrated microembolic filter with 40 µm pores.[8] The closed cell stent is designed to achieve optimal performance across radial strength, vessel coverage and flexibility, and features a unique asymmetric hourglass design that is flared at both ends to facilitate wall apposition in tortuous anatomy.[8] The integrated filter is designed to capture both macro- and micro-emboli during the entire procedure.[8] The Neuroguard IEP System is indicated for adult patients with clinically significant carotid artery stenosis requiring stenting.[8]

Spinal Elements, a spine technology company, recently announced the 510(k) clearance in the **Lucent® 3D line of 3D-printed interbody devices**.[9] In developing Lucent 3D, Spinal Elements has taken advantage of the unique capabilities of 3D printing by printing a functionally unique multi-component device in a single printing step.[9] The resulting Lucent 3D implant is comprised of a strut-and-lattice structure with a bone graft chamber access lid designed to allow the surgeon to deliver a large amount of tightly packed graft inside the interbody structure, maximizing the amount of graft material available for fusion.[9] Furthermore, when the access lid to the graft chamber is closed, the lid is designed to help distribute the loads of the spine in order to reduce the incidence of subsidence by having more surface area available for load distribution.[9] The Lucent 3D family of devices is designed to maximize bone graft volume and contain delivery of graft material.[9]

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Government News

By Carl Simon, Government News Editor

NEW INDUSTRY STANDARD GUIDE FOR CHARACTERIZING FIBER-BASED SCAFFOLDS

ASTM F3510 Standard Guide for Characterizing Fiber-Based Constructs for Tissue-Engineered Medical Products was published in May 2021.[1] The concept for the standard was first presented at the ASTM Committee F04 Medical and Surgical Materials and Devices November 2017 meeting. In August 2018, an ASTM workshop with support from ARMI BioFabUSA and Standards Coordinating Body was held at the "mill," which is the ARMI facility in Manchester New Hampshire. Entitled, "Characterization of Fiber-Based Scaffolds," the workshop was used to identify standards and measurement needs, collect feedback on the content and kick off the working group.[2] The working group had 33 members including representation from a majority of U.S. medical fiber manufacturing firms. Conference calls were held over the next two years to generate an outline, deliberate content and compose the draft. F3510 has 18,000 words and 222 references to documents including ASTM standards, ISO standards, literature references and other reference documents from the FDA, USP, PDA, ICS, NIST SRMs and 21CFR.

Structural characterization was the major topic at the workshop and is the largest section in the document (seven pages). More than 20 structural tests are addressed in terms of their assumptions, strengths and weaknesses. Mechanical characterization was the next longest section (three-and-a-half pages) where the tests that are relevant for a given clinical indication are discussed. Other sections include physical characterization (two-and-a-half pages), chemical characterization, degradation and biological characterization. The standard concludes with a two-page section on manufacturing that references 50 documents, many of which are recently published.

VETERANS ADMINISTRATION ADVANCES 3D PRINTING FOR POINT OF CARE USE

The Veterans Health Administration (VHA) 3D Printing Network Initiative is a diverse group of physicians, orthotists, prosthetists, engineers, administrators and information technologists across the VA system who advance individualized patient care through 3D printing.[3] The mission of the Veteran's Administration is to fulfill President Lincoln's promise "to care for those who shall have borne the battle," by serving and honoring the men and women who are America's veterans. The initiative uses 3D printing for three main focus areas: pre-surgical planning to precisely calibrate a surgical approach, manufacturing specialized orthotics and assistive technology to provide same-day fitting and delivery and fabricating replacement tissues that are customized to an individual patient. The initiative started in three hospitals and has expanded to nearly forty (Figure 1). The initiative is led by Dr. Beth Ripley, a radiologist, and it aims to understand how patient-specific 3D printing can improve the safety and quality of diagnoses and interventions such as surgery and minimally invasive procedures, patient education, shared decision-making, and informed consent, and also improve how patients engage with their surroundings. The questions they are trying to answer include: What does process control for point of care (POC) biomanufacturing look like? What testing is needed? How will this be regulated? How do we train hospital technicians and surgeons to do POC biomanufacturing? Who should be involved?

Please reach out to Dr. Ripley for more information: beth.ripley2@va.gov.

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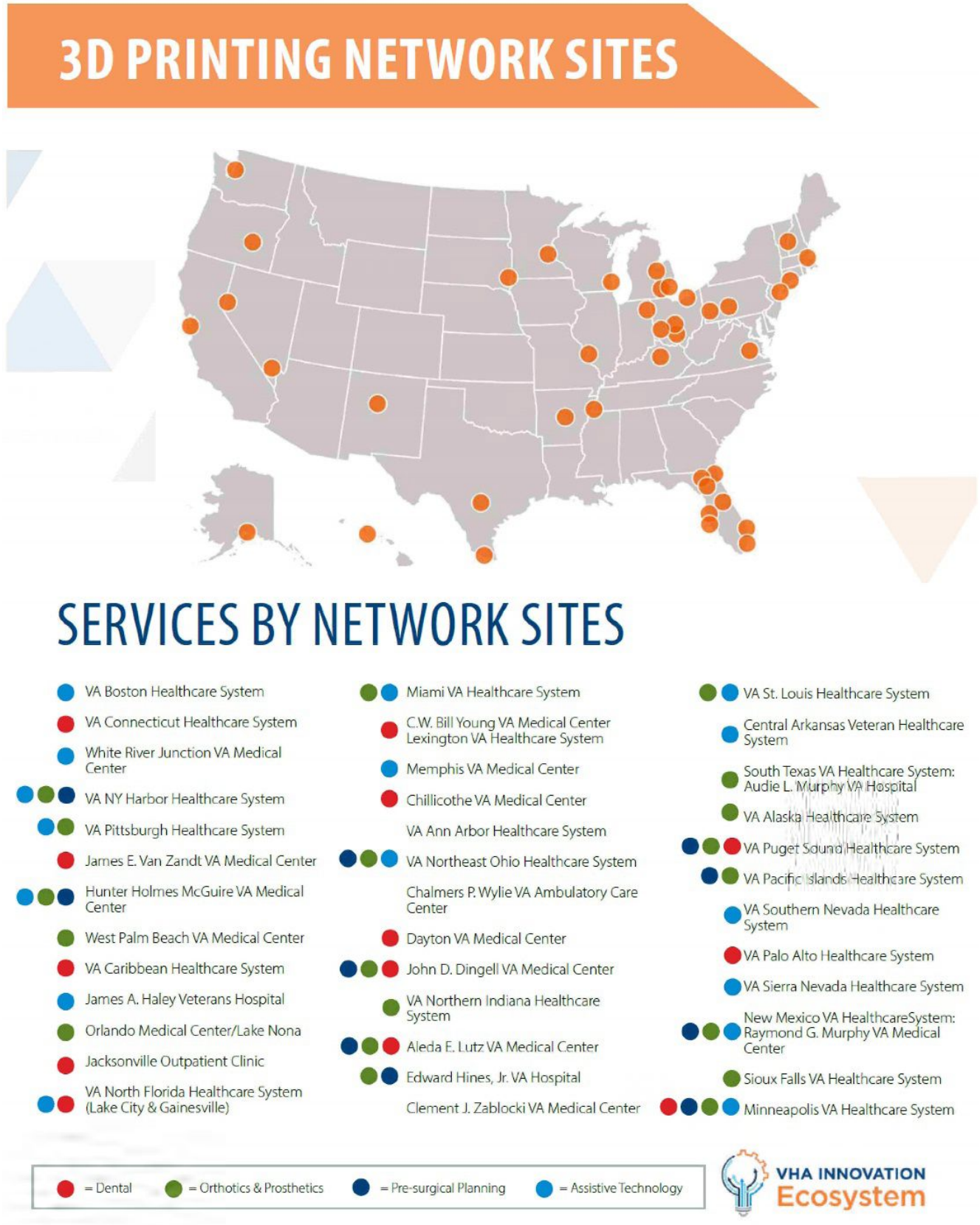

Fig 1. Map of hospitals in the VHA 3D Printing Network.

In Memoriam

JONATHAN BLACK, F.B.S.E. (1939-2020)

"A MATCH CAN LIGHT A TORCH BUT WILL NEVER BLAZE AS LONG OR AS BRIGHTLY."

— P. Elaine Duncan, *The Torch*, September 1986

By Martine LaBerge, PhD (reprinted with permission from Dr. LaBerge, originally appearing in the Clemson Bioengineering Newsletter, *Spring 2021)*

Jonathan Black was one of a kind and will be dearly missed. Spirited, opinionated, caring and a mentor to all who would seek his help, Black never left an opportunity to trigger controversy and positivity. He challenged everyone to think, innovate and give the very best. He supported colleagues at many stages of their career, developing wonderful friendships based on science and biomaterials.

Who did not fear Jonathan's comments? "It was always with some trepidation that anyone would watch Professor Black approach a microphone at an SFB or ORS meeting after some poor resident or grad student or professor had just given a talk," Jeremy Gilbert, PhD, said. "You knew what was coming would not be pretty, but it would make you think, the speaker squirm and the audience cringe."

Black's academic career, a wealth of success stories, impacted three institutions: University of Pennsylvania (1971-1988), Clemson University (1988-1993; 1993-2020 as professor emeritus) and Cornell University (2011-2015). Black joined the faculty at Clemson as the inaugural Hunter Endowed Chair in Bioengineering, the first chair worldwide devoted to biomaterials science and engineering. One could wonder if he ever thought, after receiving the1986 Clemson Award for Contributions to the Literature from the Society For Biomaterials, that he would one day be recognized as a cornerstone of the birthplace of biomaterials?

In his plenary address at the 1986 SFB Annual Meeting, he compared the study of biomaterials to the story of the three blind men who find an elephant and attempt to describe it, speaking on "Biological Response to Materials: Three Aspects of the Elephant." Black's colorful reputation as a storyteller and an engaging eccentric helped promote the field of biomaterials and the Society For Biomaterials, for which he served as President in 1982-1983. Under Black's presidency, the Founder's Award was instigated, and for the first time, separate poster presentations were displayed as part of the annual meeting program. That Annual Meeting drew the largest number of participants to date, with 600 people attending and 256 papers contributed. The biomaterials community took a major step forward in its efforts for extensive exchange of research findings among colleges worldwide with its improvements to the International Liaison Committee. By that time, all five constituent international societies had agreed to reciprocity with registration fees for all members.

As an educator, Black merged philosophy and engineering, triggering excitement in the classroom. His classes on biomaterials were highly sought by students and colleagues: He crafted his lectures spontaneously, without notes, pacing and reflecting on engineering and physics fundamentals and never neglecting to mention that creative avoidance is the place where innovation is defined.

One of the pioneers in the field of orthopaedic biomaterials, Black's seminal work on corrosion is still cited today. He inspired generations to serve science with perseverance.

"One of my many wonderful memories about Jonathan, which gave me my first real experience of his uniqueness," Robert

In Memoriam Jonathan Black, F.B.S.E. (continued)

Latour, PhD, said, "was during the banquet of the Society for Biomaterials Conference at the Waldorf-Astoria hotel in New York City in June 1987. I was in my second year of graduate school. Jonathan and his group were sitting together at one of the banquet tables. As I recall, the banquet meal was a nice chicken dish for about 700 or so attendees. When the server got to our table and started to place a plate in front of Jonathan, he looked up at the waiter and said, "I think I will have fish instead." Without skipping a beat, the waiter picked back up Jonathan's plate and returned about 15 minutes later with a nice fish dinner plate. So, 699 people had chicken that night and Jonathan had fish. That event told me a lot about this unique individual. He certainly was one of a kind!"

In 2011, Clemson's Bioengineering Department recognized Black's legacy to the world of biomaterials and innovation by establishing the Jonathan Black Undergraduate Leadership Award. It is given annually to an outstanding undergraduate student for leadership and service in addition to scholastic excellence, exemplifying Black's craftsmanship as an educator, leader, author and philosopher.

Jonathan Black has left big shoes to fill; he carried the Torch to the end with inspirational dedication. An exemplary role model like no other!

"I enjoyed and appreciated interactions with Jonathan Black and his family for over more than four decades. Our differing opinions resulted in lively debates that always reached a position favoring the discipline, and especially the scientific content needed for the future. Jonathan seemed to enjoy the process, especially at conferences where lengthy discussion was permitted. After one debate at SFB, I met with Jonathan and told him that some of the information he presented was not fully representative of what happened. Much to my surprise, he agreed, and he added that his position was the most accepted by those listening and the information was of significant value. I could not disagree with that thought.

Although contact has been limited in recent years, I often think — what would be his position? I regret that new students will not gain the benefit of his approach and opinions.

I already miss him and extend my thoughts to the family."

—Jack Lemons, PhD

"One of the pioneers in the field of orthopaedic biomaterials, Black's seminal work on corrosion is still cited today. He inspired generations to serve science with perseverance."

—Martine LaBerge

Don Lyman at the World Biomaterials Congress, Kyoto 1988

Photo credit: Buddy D. Ratner

In Memoriam

DONALD J. LYMAN: A THOUGHT-LEADER IN THE EVOLUTION OF BIOMATERIALS SCIENCE

By Buddy D. Ratner

The last issue of Biomaterials Forum *featured a tribute to Dr. Lyman by his wife, Elizabeth Lyman. In this issue, Dr. Ratner offers his personal reflections on Dr. Lyman's impact, as a colleague and friend.*

Don Lyman left us in late 2020 at age 94 after a career in science spanning more than 65 years. His influence on the development of biomaterials science will be remembered for its impact and vision. I was honored to have known Don through a good fraction of his active career and to have been influenced by his visionary ideas and his quality publications. Importantly, at this moment, I am also emotionally moved by the loss of a true gentleman with an easy-going, friendly personality and a strong sense of commitment to his students, colleagues and to science.

Donald Lyman received his PhD in chemistry from the University of Delaware in 1952. After a stint at the Pioneering Research Laboratory, E.I. DuPont de Nemours and Company in Wilmington, Delaware, he joined the Stanford Research Institute (SRI) in 1961 at the invitation of noted SRI chemist, Maurice Huggins (of Flory-Huggins theory fame). SRI was important to biomaterials science in those days because it was an early home to polymer chemistry — a field just emerging as a legitimate discipline in its own right, and also connected to early medical devices through research contracts with the NIH. At SRI, Don Lyman was closely associated with the development of polyetherurethane materials that were important in the early development of the artificial heart. While at SRI, Don heard a lecture by Belding Scribner, the nephrologist who made kidney dialysis a reality for millions of end-stage renal failure patients. This influenced Don's nascent interests in polymer membrane technology in the direction of improving dialysis filters.

Willem Kolff, then-Director of University of Utah's inaugural Institute of Biomedical Engineering (pre-Department) and Division of Artificial Organs (in the Department of Surgery) was probably the key recruiter to get Don to move to Utah in 1969. When Don moved to the University of Utah as a professor in the then-Division of Materials Science and Engineering and the Department of Surgery's Division of Artificial Organs, he launched programs in biomaterials for kidney dialysis and cardiovascular devices. Don was an original member of Utah's new Department of Bioengineering in 1974 and remained as a Professor at the University of Utah till his retirement in 1989. He then became Professor Emeritus, continuing his research activities well after his retirement. In fact, in his last paper, published in 2017, he continued to list the University of Utah and the Department of Bioengineering as his affiliation. He published roughly 170 papers during his career, contributing to an impressive range of subjects. These include dialysis membranes, blood compatibility, protein adsorption, polyurethanes, infrared and ESCA characterization of biomaterials and natural tissue, vascular grafts and even a paper on the use of infrared spectroscopy to assess the quality of brewed coffee.

Some of Don Lyman's published studies that have influenced me include:

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  (This was important because it introduced the adsorbed albumin hypothesis for blood compatibility, a hypothesis I subscribe to right up to this very day)

In Memoriam Donald J. Lyman (continued)

- Lyman DJ. Polyurethanes - The chemistry of the diisocyanate-diol reaction. In: Solomon DH, Ed., *Step-Growth Polymerizations*, Marcel Dekker, Inc.;1972:pp 95–113.
  (I learned much about polyurethane synthesis from this review. We are still synthesizing novel biomedical polyurethanes in my lab.)
- Lyman DJ, Albo D Jr., Jackson RT, et al. Development of Small Diameter Vascular Prostheses. *Trans Am Soc Artif Inter Organs*. 1977;23:253-260.
  (I appreciated the use of ESCA and FTIR for the characterization of polymers and the early thinking on vascular graft performance.)

In the last set of studies that Don published, his focus turned to breast cancer. He used his skills with FTIR spectroscopy to assess changes in hair chemical structure to establish relationships with breast cancer that might lead to a new diagnostic method. The final paper in this series was published in 2017.

Don Lyman collaborated with many well-known names in the biomaterials field, and some not so well-known. His collaborators and co-authors included Jorge Heller, John Brash, Willem Kolff, Bruce Fritzinger, Sharon Brauman, Clifford Kwan-Gett, Joe Andrade, Sung Wan Kim, Dominic Albo, Jr., Adrian Bantjes, Jan Feijen, Kristine Knutson, Adam Baszkin and Jacqueline Murray-Wijelath.

Donald Lyman graduated more than 20 Masters and PhD students. He, along with Joe Andrade, founded the Department of Bioengineering at the University of Utah. He received the Clemson Award for Basic Research from the Society For Biomaterials. He became Director of Polymer Chemistry at the Hope Heart Institute in Seattle. He was the founder and host of the Science Café of Olympia, Washington (in cooperation with the Puget Sound Section of the American Chemical Society), a project to educate the general public on advances in science. His life was rich with accomplishment, leadership and vision. His scientific studies have impacted generations of biomaterials scientists. Donald J. Lyman will be missed by those who knew and appreciated him. His legacy will live on through his publications and those he mentored or with whom he collaborated.

I acknowledge Professor David Grainger of the University of Utah for his suggestions and comments on this remembrance.

Don Lyman in discussions with participants at a biomaterials meeting, Siena, Italy, 1993
Photo credit: Buddy D. Ratner

Don Lyman and Jack Lemons at a UWEB meeting 1999
Photo credit: Buddy D. Ratner

Don Lyman (5th from left, back row) at an SFB history conference held at Clemson Uinversity
Photo credit: Society For Biomaterials

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