

SB<sup>3</sup>C

biomechanics.  
bioengineering.  
biotransport.

**2020 Summer  
Biomechanics,  
Bioengineering, and  
Biotransport Conference**



*Virtual Meeting*  
June 17-20, 2020  
**Program Book**

Funding for this conference was made possible (in part) by the National Science Foundation's Civil, Mechanical and Manufacturing Innovation Division (Biomechanics and Mechanobiology) #2017872.

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Prizes and other support for the Student Paper Competition were provided by the Bioengineering Division of the American Society of Mechanical Engineers.

**The 2020 Summer Biomechanics, Bioengineering, and Biotransport Conference (SB<sup>3</sup>C) organizers gratefully acknowledge the support of the National Science Foundation, the National Institutes of Health, and American Society of Mechanical Engineers.**



Congratulations to this year's Cover Art Contest winner:

**William Wang, University of Michigan**

*Title: Rainbow Sprouts*

Description: Z-depth encoded endothelial cell sprouts invading into 3D extracellular matrix from a parent vessel using a multiplexed angiogenesis-on-a-chip platform.

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# 1 Forward and Acknowledgement

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Dear SB<sup>3</sup>C Community,

*Opening Remarks:* On behalf of the entire SB<sup>3</sup>C 2020 Organizing Committee, we hope that you and your families have remained safe and healthy during the ongoing COVID-19 pandemic. In an effort to limit person-to-person contact to prevent the spread of the virus, we took the decision in March to cancel our in-person meeting and replace it with a safer alternative. In constructing the conference, we sought to preserve SB<sup>3</sup>C's rich scientific experience in a way that balanced the needs of our community to communicate their research, while respecting their absolute right to stay healthy. The result of our efforts is the 2020 Virtual Summer Biomechanics, Bioengineering, and Biotransport Meeting. We welcome you all and we thank you for your scientific contributions. While we are unable to provide the same intimacy and collegiality for which SB<sup>3</sup>C meetings are typically known, we can promise you that our program will provide SB<sup>3</sup>C's usual high-quality, state of the art bioengineering research along with an enhanced ability to connect (albeit digitally) with our vibrant community.

*In Memoriam:* This year we are saddened by the loss of two giants who helped create the foundational work on which much of our collective fields are based: Dr. Robert Nerem and Dr. YC Fung. Our dear friend and colleague, Dr. Nerem, has been a leader and an agent for change in the field of bioengineering for many years. We would like to thank Ross Ethier for putting together a fitting tribute to Dr. Nerem in this Program Book and we strongly encourage you to take the time to read it and join us in celebrating his life as a world-class researcher, leader, collaborator, and truly wonderful person. Dr. Fung, ostensibly the father of modern biomechanics, was a founder of the Journal of Biomechanics and author of multiple seminal and beloved books on Biosolid and Biofluid mechanics that reside prominently on many of our bookshelves. We would also like to thank Dr. Savio Woo who carefully assembled a wonderful memoriam for Dr. Fung included in this Program Book. Dr. Fung's legacy and visionary contributions to the study of biomechanics are unequaled and will continue to shape the future research of so many of us for years to come.

*Conference Structure:* The program for this year's virtual conference required some re-organization and altered planning that we hope you will enjoy. We continue the tradition of honoring the ASME medal winners through a live, virtual web conference webinar. The H.R. Lissner Medal winner, Dr. Larry Taber, is honored for ground-breaking work that has enabled a new understanding of how mechanics plays a role in growth and development, in addition to his educational impact and service to ASME-BED. Dr. Mehmet Toner, winner of the Savio L-Y. Woo Translational Biomechanics Medal, is honored for his multi-disciplinary research clinical implications to cancer, wound healing, regenerative medicine, burns and trauma, infectious disease, and global health. Dr. Stavros Thomopoulos will receive the Van C. Mow Medal for pioneering research in the development, biomechanics, and healing of tendon-to-bone attachments; Dr. Matthew Fisher will receive the Y.C. Fung Early Career Medal for exceptional translational orthopaedic research; and Dr. Dawn Elliott will receive the Robert M. Nerem Education and Mentorship Medal for investing in the personal and professional development of her trainees and colleagues (including your Conference Chair!). We congratulate all of the awardees and encourage you to attend their live presentations.

*Student Paper Competition:* Continuing our long tradition of elevating the work of our trainees, the ASME PhD Student Paper Competition (SPC) finalists will present their work live during the meeting, please tune in to see their exceptional presentations. The ASME MS and BS competitions will be presented in a recorded asynchronous format. We would like to thank ASME for sponsoring our student competitions – which have become a unique and critical part of our annual conference. The organizing committee would also like to acknowledge the numerous people that have offered their time to serve as SPC judges this year – thank you very much.

*Acknowledgements:* This year has been especially challenging and we would like to thank our SB<sup>3</sup>C Conference Organizing Committee who have worked tirelessly to ensure we have a quality 2020 event that serves our community well. We would also like to thank Pat Cinfici, Debbie Pasquale, Laurie Cruz, and all of the folks at Boscov's Travel for their continued support of SB<sup>3</sup>C. This year's conference (as well as the 2021 conference) would not have been possible without their strong advocacy and generous hard work. Last but certainly not least, we wholeheartedly thank the NIH and the NSF for conference funding and the ASME-BED Technical Committees, the Student Leadership Committee, and the SB<sup>3</sup>C Foundation Board for their continued support. We hope that you will enjoy our virtual conference this year and we look forward to seeing you in person in Vail in June 2021!

**Jonathan Vande Geest, Conference Chair**  
University of Pittsburgh

**Jeffrey Ruberti, Program Chair**  
Northeastern University

## 1.1 Virtual Conference Code of Conduct

All participants, speakers, sponsors and volunteers of this virtual conference are required to agree with the following code of conduct. Conference organizers expect cooperation from all participants to help ensure a safe environment for everybody. Our conference is dedicated to providing a harassment-free conference experience for everyone, regardless of gender, gender identity and expression, age, sexual orientation, disability, physical appearance, body size, race, ethnicity, religion (or lack thereof), or technology choices. We do not tolerate harassment of conference participants in any form. Sexual language and imagery is not appropriate for any conference activity, including talks, comments, Twitter, and other online media. Conference participants violating these rules may be sanctioned or removed from the conference without a refund at the discretion of the conference organizers. Participants that witness or experience violations to the above code of conduct should report these immediately to the conference chair via email (Jonathan Vande Geest; [jpv20@pitt.edu](mailto:jpv20@pitt.edu)).



## 1.2 Program-at-a-Glance

## SB3C 2020 - Virtual Meeting Program At A Glance

	Time	Session
WEDNESDAY June 17, 2020	10:00am - 10:50am EDT	ASME BED Education TCOM Meeting
	11:00am - 11:50am EDT	ASME BED Cell & Tissue Eng TCOM Meeting
	12:00pm - 12:50pm EDT	ASME BED Biotransport TCOM Meeting
	1:00pm - 2:30pm EDT	PhD Student Paper Competition Session 1
	3:00pm - 4:00pm EDT	Fung and Mow Lectures
	4:00pm - 4:30pm EDT	ASME BED Open Meeting
	4:30pm - 6:00pm EDT	PhD Student Paper Competition Session 2

	Time	Session
THURSDAY June 18, 2020	10:00am - 10:50am EDT	ASME BED Solids TCOM Meeting
	11:00am - 12:30pm EDT	PhD Student Paper Competition Session 3
	1:00pm - 2:00pm EDT	Woo and Nerem Lectures
	2:30pm - 4:00pm EDT	PhD Student Paper Competition Session 4
	4:00pm - 5:00pm EDT	MS Student Paper Competition Live Q&A
	5:00pm - 6:30pm EDT	DMME Virtual Meeting

	Time	Session
FRIDAY June 19, 2020	10:00am - 10:50am EDT	ASME BED Fluids TCOM Meeting
	11:00am - 12:30pm EDT	PhD Student Paper Competition Session 5
	1:00pm - 2:00pm EDT	Lissner Lecture
	2:30pm - 4:00pm EDT	PhD Student Paper Competition Session 6
	4:00pm - 5:00pm EDT	BS Student Paper Competition Live Q&A
	5:30pm - 6:30pm EDT	Student Leadership Committee Meeting
	6:30pm - 8:30pm EDT	Student Trivia Night

	Time	Session
SATURDAY June 20, 2020	10:00am - 10:50am EDT	ASME BED Design, Dyn & Rehab TCOM Meeting
	11:00am - 12:30pm EDT	Undergraduate Design Competition
	1:00pm - 3:00pm EDT	Women's Networking Event

## 2 Conference Organizing Committees

### 2.1 Organizing Committee



**Jonathan Vande Geest, Conference Chair**  
University of Pittsburgh



**Jeffrey Ruberti, Program Chair**  
Northeastern University

**Brittany Coats**, Information Chair, University of Utah  
**Craig Goergen**, Publications Chair, Purdue University  
**Spencer Lake**, Local Arrangements and Finance Chair, Washington University in St. Louis  
**Luke Timmins**, Exhibits Chair, University of Utah  
**Rebecca Heise**, Diversity Chair, Virginia Commonwealth University  
**Sara Roccabianca**, Student Paper Competition Chair, Michigan State University  
**Joel Boerckel**, Media Chair, University of Pennsylvania  
**Justin Scott**, Student Leadership Chair, Michigan State University

## 2.2 Program Committee

**Jeffrey Ruberti**, Chair, Program Committee, Northeastern University  
**Xiaoming (Shawn) He**, Chair, Biotransport Technical Committee, University of Maryland  
**Rafael Davalos**, Co-Chair, Biotransport Technical Committee, Virginia Tech University  
**Michael Moreno**, Chair, Design, Dynamics, & Rehab Tech. Committee, Texas A&M University  
**Anita Singh**, Co-Chair, Design, Dynamics, & Rehab Tech. Committee, Widener University  
**Stephanie George**, Chair, Education Committee, East Carolina University  
**Victor Lai**, Co-Chair, Education Committee, University of Minnesota Duluth  
**John LaDisa**, Chair, Fluids Tech. Committee, Marquette University  
**Alejandro Roldan-Alzate**, Co-Chair, Fluids Tech. Committee, University of Wisconsin-Madison  
**Suresh M. L. Raghavan**, Chair, Industry Committee, University of Iowa  
**Ethan Kung**, Co-Chair, Industry Committee, Clemson University  
**Vicky Nguyen**, Vice Chair, Solid Mechanics Committee, Johns Hopkins University  
**Kristin Myers**, Co-Chair, Solid Mechanics Committee, Columbia University  
**Ed Guo**, Chair, Cell & Tissue Engineering Technical Committee, Columbia University  
**Grace O'Connell**, Vice Chair, Cell & Tissue Engineering Technical Committee, UC Berkeley  
**Justin Scott**, Chair, Student Leadership Chair, Michigan State University

## 2.3 Student Paper Competition Committee

**Sara Roccabianca**, Chair, PhD Level, Michigan State University  
**Ian Sigal**, PhD Level, University of Pittsburgh  
**Joao Soares**, MS Level, Virginia Commonwealth University  
**Kristin Miller**, BS Level, Tulane University

## 2.4 Undergraduate Design Competition Committee

**Michael Moreno**, Chair, Texas A&M University  
**Ted Conway**, Co-Chair, Florida Institute of Technology

Thank you to all committee members!

### 3 Awards



1977 Robert W. Mann  
 1978 Y.C. Fung  
 1979 Robert F. Rushmer  
 1980 F. Gaynor Evans  
 1981 Max Anliker  
 1982 R.M. Kenedi  
 1983 Henning E. von Gierke  
 1984 Perry L. Blackshear  
 1985 Richard Skalak  
 1986 Albert H. Burstein  
 1987 Van C. Mow  
 1988 Alf Louis Nachemson  
 1989 Robert M. Nerem  
 1990 Albert B. Schultz  
 1991 Savio Lau-Yuen Woo  
 1992 John C. Chato  
 1993 Don P. Giddens  
 1994 Sheldon Weinbaum  
 1995 Robert E. Mates  
 1996 Albert I. King  
 1997 Ajit P. Yoganathan  
 1998 Malcolm H. Pope  
 1999 Stephen C. Cowin  
 2000 Morton H. Friedman  
 2001 W. Michael Lai  
 2002 Kenneth R. Diller  
 2003 Vijay K. Goel  
 2004 John M. Tarbell  
 2005 Steven A. Goldstein  
 2006 Peter A. Torzilli  
 2007 Maury L. Hull  
 2008 Noshir A. Langrana  
 2009 Thomas P. Andriacchi  
 2010 Roger D. Kamm  
 2011 Jay D. Humphrey  
 2012 David Butler  
 2013 Mehmet Toner  
 2014 Kyriacos A. Athanasiou  
 2015 James A. Ashton-Miller  
 2016 Roger C. Haut  
 2017 Gerard A. Ateshian  
 2018 Louis J. Soslowsky  
 2019 Jennifer S. Wayne  
 2020 Larry A. Taber

### H. R. Lissner Medal

The H.R. Lissner Medal recognizes outstanding achievements in the field of bioengineering. These achievements may be in the form of (1) significant research contributions in bioengineering; (2) development of new methods of measuring in bioengineering; (3) design of new equipment and instrumentation in bioengineering; (4) educational impact in the training of bioengineers; and/or (5) service to the bioengineering community, in general, and to the Bioengineering Division of ASME, in particular. The Bioengineering Division of ASME established the H. R. Lissner Award as a divisional award in 1977. It was upgraded to a society award in 1987, made possible by a donation from Wayne State University and is named in honor of Professor H. R. Lissner of Wayne State University for his pioneering work in biomechanics that began in 1939.

### 2020 Larry A. Taber, PhD

Larry A. Taber, Ph.D., for seminal work that has enabled a new understanding of the mechanics of growth and development, particularly for rigorous models, based on nonlinear elasticity and mechanical feedback and supported by clear experiments, that explain how the embryonic heart and brain take shape. He is a Senior Professor of Biomedical Engineering and of Mechanical Engineering and Materials Science at Washington University in St. Louis. From 2007 until his retirement in 2017, he was the Dennis and Barbara Kessler Professor of Biomedical Engineering. He moved to Washington University in 1997, after spending four years at the General Motors Research Laboratories and 15 years at the University of Rochester.

Dr. Taber is a fellow of ASME and the American Institute for Medical and Biological Engineering. Three times he won the Richard Skalak Award for the best paper published in the Journal of Biomechanical Engineering (2004, 2007, 2015). From 2011-2016, he served as co-editor-in-chief of the journal Biomechanics and Modeling in Mechanobiology. Although his formal training is in aerospace engineering (B.A.E., Georgia Tech; Ph.D., Stanford University), he has published more than 100 journal articles on a wide range of topics including cochlear mechanics, nonlinear shell theory, cardiovascular mechanics, and the mechanics of growth and development. He has published two books: Non-linear Theory of Elasticity: Applications in Biomechanics (2004) and Continuum Modeling in Mechanobiology (2020). Beginning in 1990, he pioneered studies of the mechanics of organogenesis. His work integrates theoretical/computational modeling with experiments on embryos to study the role of mechanical forces in heart, brain, and eye morphogenesis. Understanding the mechanics of embryonic development could one day lead to new strategies for tissue engineering, tissue regeneration, and the prevention and treatment of congenital malformations.





## Savio L-Y. Woo Medal



2016 Baruch Barry Lieber  
 2017 Arthur Erdman  
 2018 Kyriacos A. Athanasiou  
 2019 Rita M. Patterson  
 2020 Mehmet Toner

The Savio L-Y. Woo Translational Biomechanics Medal was established in June 2015 as a society-level award and recognizes a sustained level of meritorious contributions in translating bioengineering research to clinical application, to improve the quality of life. This award is named in honor of Savio Lau-Yuen Woo, Ph.D., Distinguished University Professor of Bioengineering and the Founder and Director of the Musculoskeletal Research Center (MSRC), a diverse multidisciplinary research and educational center in the Department of Bioengineering at the University of Pittsburgh. Beyond pioneering and world-renowned scholarly contributions, Professor Woo has made an enormous impact in 40 years of translational research that has significantly contributed to the delivery of healthcare. Any member of ASME who has demonstrated a sustained level of outstanding achievement in translating bioengineering findings to the clinical community may be eligible for this medal.

## 2020 Mehmet Toner, PhD

Mehmet Toner, PhD, holds the Helen Andrus Benedict Professor of Biomedical Engineering at the Massachusetts General Hospital, Harvard Medical School, and Harvard-MIT Division of Health Sciences and Technology. He serves as the Director of Research at the Shriners Hospitals for Children in Boston, the Co-Director of the Center for Engineering in Medicine and Surgery, and the Director of Bio-MicroElectroMechanical Systems Resource Center at the MGH.

His biomedical engineering contributions represent examples of multidisciplinary research or the so-called convergence science with clinical implications in cancer, wound healing, regenerative medicine, burns and trauma, infectious disease, and global health. His work in low temperature thermodynamics and biopreservation of cellular systems spans both fundamental and applied aspects of cryopreservation of cells, gametes, tissue constructs, engineered tissues, and whole organs. In microelectromechanical devices, his group was the first to use microfluidics to isolate extremely rare circulating tumor cells (CTCs) from peripheral blood with applications in the diagnosis and monitoring of cancer patients. Dr. Toner has also pioneered using inertia in microfluidic systems by demonstrating that inertia is not only critical to low Reynolds number flows in microchannels but it is also extremely useful and easily exploited in these systems to achieve amazing control over manipulation of bioparticles and cells. In tissue engineering, Dr. Toner pioneered a "lift-off" concept to make largely inorganic microfabrication approaches compatible with biological systems. Direct descendants of these methods are now being used today throughout the world to create cellular patterns and engineered tissues of various sorts. Dr. Toner also led the development of a microengineered bioartificial liver system that overcomes the major transport-related shortcomings of the current clinical bioartificial liver systems through the use of a flat plate hepatocyte microreactor.



One of the most important accomplishments of Dr. Toner is his dedication to the training of the next generation biomedical engineers. Many of his trainees are now leading their own independent research groups or companies. Dr. Toner has received acclaim for his ability to converge academic-clinical-industrial interactions and holds more than 50 patents emerged from his group that resulted in the creation of multiple companies. In 1994, he was recognized by the "YC Fung Young Award" in Bioengineering. In 1998, Dr. Toner was selected to become a "Fellow of the American Institute of Medical and Biological Engineering." In 2007, he became a "Fellow of the American Society of Mechanical Engineers." In 2008, he also became a "Fellow of the Society for Cryobiology." In 2012, he was given the "Luyet Medal" by the Society for Cryobiology. In 2013, he received the "H.R. Lissner Medal" for his contributions to bioengineering. Dr. Toner is inducted to the Turkish Academy of Science, National Academy of Inventors, the National Academy of Engineering, and the National Academy of Medicine.

### Robert M. Nerem Education and Mentorship Medal

The Robert M. Nerem Education and Mentorship Medal is given to an individual who has demonstrated a sustained level of outstanding achievement in education and mentoring of trainees. Examples of meritorious activities include leadership within the nominee's institution, mentoring activities that are above and beyond those expected from others employed in similar positions, mentoring activities tailored to meet the needs of the trainees, and innovative mentoring activities.

### 2020 Dawn M. Elliott, PhD

Dawn Elliott, PhD, Blue and Gold Distinguished Professor and Chair of Biomedical Engineering at the University of Delaware, for exemplary mentorship, including her students, individuals in her academic community, and educational workshops; for contributions to excellence in engineering education, including starting a new department and leadership in professional societies; and for impact to diversity in engineering. Dr. Elliott is a leader in the field of musculoskeletal biomechanics. She investigates the changes that occur in load-bearing fibrous tissues, such as disc, meniscus, and tendon with degeneration, injury, and following interventions. Her multi-scale approach, from the entire joint-level, to the tissue-scale and micro-scale, integrates mechanical testing, mathematical modeling, and multi-modal imaging. In 2015 she was awarded the American Society of Mechanical Engineers (ASME) Van C. Mow Medal for significant contributions to the field of bioengineering and in 2018 she was awarded the inaugural Orthopaedic Research Society Adele L. Boskey Award for excellence in impactful research and mentorship.



2018 Roger D. Kamm  
2019 Kenneth R. Diller  
2020 Dawn M. Elliott

Dr. Elliott has been an outstanding teacher, mentor, and contributor to the professions of biomedical engineering and orthopaedics. After twelve years faculty in Orthopaedics at the University of Pennsylvania, where she was promoted to full professor, she joined the University of Delaware in 2011 to start their Biomedical Engineering Department. Under her leadership, over the last ten years the department has grown in size and impact, twice earned ABET accreditation, and is already ranked among the top third of U.S. BME departments. In recognition for these contributions, Dr. Elliott was awarded the inaugural Outstanding Achievement in Mentoring Award from the Orthopaedic Research Society. Dr. Elliott is a Fellow of ASME and the American Institute for Medical and Biological Engineering (AIMBE). She had made many contributions to the ASME Bioengineering Division, including: chair of the Solid Mechanics committee (2007-2010), Program Chair of the Summer Bioengineering Conference (SBC, 2009), Conference Chair of SBC (2012), and Executive Committee member at large (2009-2012). She is currently the Chair of the Mow Medal Awards committee. Outside of ASME, Dr. Elliott is currently President of the Biomedical Engineering Society (BMES) where she previously served as Treasurer and on the Board. She is on the Board of Directors of The Perry Initiative, a non-profit organization dedicated to increasing role of women in engineering and medicine. She was on the founding Board and past President of the SB<sup>3</sup>C Foundation.



## Van C. Mow Medal

The Van C. Mow Medal is bestowed upon an individual who has made significant contributions to the field of bioengineering through research, education, professional development, leadership in the development of the profession, as a mentor to young bioengineers, and with service to the bioengineering community. The individual must have earned a PhD or equivalent degree between ten and twenty years prior to June 1 of the year of the award. The award was established by the Bioengineering Division in 2004.

### 2020 Stavros Thomopoulos, PhD

Stavros Thomopoulos, PhD, is the Robert E. Carroll and Jane Chace Carroll Professor of Biomechanics (in Orthopedic Surgery and Biomedical Engineering), the Director of Carroll Laboratories for Orthopedic Surgery, and the Vice Chair of Basic Research in Orthopedic Surgery at Columbia University. As the director of the Carroll Laboratories and the vice chair of basic research, he is leading an effort to engage orthopedic surgeons in basic and translational research by enhancing collaborations between engineering faculty and clinical faculty and by expanding core facilities for musculoskeletal research. His laboratory is studying the development, biomechanics, and healing of the tendon-to-bone attachment (the “enthesis”), with a focus on solving the clinical challenge of repairing torn rotator cuff tendons. This collaborative effort includes a team of mechanical engineers, biomedical engineers, orthopaedic surgeons, and developmental biologists. The research, funded by several NIH grants, is motivated by the mechanical challenge of attaching dissimilar materials such as tendon and bone. To develop successful strategies for tendon-to-bone repair, the team is focusing on understanding enthesis biomechanics, understanding enthesis developmental biology, implementing this understanding using regenerative medicine strategies, and testing these strategies in clinically relevant animal models. These four research themes inform each other and will be translated to clinical therapies for tendon-to-bone repair.



2005 Kyriacos A. Athanasiou  
 2006 Robert Lie-Yuan Sah  
 2007 Lori A. Setton  
 2008 Scott L. Delp  
 2009 Michael Sacks  
 2010 Tony M. Keaveny  
 2011 David A. Vorp  
 2012 John Bischof  
 2013 Jeffrey Weiss  
 2014 Christopher R. Jacobs  
 2015 Dawn M. Elliott  
 2016 Beth A. Winkelstein  
 2017 Richard R. Neptune  
 2018 Jeffrey W. Holmes  
 2019 Tony Jun Huang  
 2020 Stavros Thomopoulos

Dr. Thomopoulos has mentored 75 trainees, including undergraduate, masters, and PhD students as well as postdoctoral fellows. He has been a member of ASME since his undergraduate junior year in 1993, and is currently an ASME fellow and the treasurer of the ASME Bioengineering Division. Previously, he served as local arrangements chair and publications chair for ASME Summer Bioengineering meetings. He will be the Conference Chair for the 2023 SB<sup>3</sup>C Meeting. Dr. Thomopoulos has received awards from the ASME, the American Shoulder and Elbow Surgeons Society, and the American Academy of Orthopaedic Surgeons. He is a fellow of The American Institute for Medical and Biological Engineering. He is an Associate Editor for the Journal of Orthopaedic Research, handling all papers related to tendon, ligament, and muscle.



## Y.C. Fung Early Career Medal

The Y. C. Fung Early Career Award is given to young investigators who are committed to pursuing research in the field of Bioengineering and have demonstrated significant potential to make substantial contributions to the field of Bioengineering. Such accomplishments may take the form of, but are not limited to, design or development of new methods, equipment or instrumentation in bioengineering; and research publications in peer-reviewed journals. The award was established by the Bioengineering Division in 1985 and operated as a division award until 1998 when it was elevated to a society award.



1986 Mark H. Holmes  
 1987 Steven A. Goldstein  
 1989 David N. Ku  
 1990 Jay D. Humphrey  
 1991 Michael Kwan  
 1992 Cheng Zhu  
 1993 John A. Frangos  
 1994 Mehmet Toner  
 1995 Cheng Dong  
 1996 Antony Keaveny  
 1997 Gerard A. Ateshian  
 1998 Louis J. Soslowsky  
 1999 Rebecca Richards-Kortum  
 2000 Farshid Guilak  
 2001 David F. Meaney  
 2002 Jeffrey A. Weiss  
 2003 Sangeeta N. Bhatia  
 2004 Richard E. Debski  
 2005 Jeffrey W. Holmes  
 2006 Beth A. Winkelstein  
 2007 Stavros Thomopoulos  
 2008 Gabriel A. Silva  
 2009 Robert Mauck  
 2010 Matthew J. Gounis  
 2011 Ali Khademhosseini  
 2012 Marissa Nichole Rylander  
 2013 Jonathan Vande Geest  
 2014 W. David Merryman  
 2015 Adam J. Engler  
 2016 Triantafyllos Stylianopoulos  
 2017 Kristin Myers  
 2018 Spencer P. Lake  
 2019 Grace D. O'Connell  
 2020 Matthew B. Fisher

## 2020 Matthew B. Fisher, PhD

Matthew B. Fisher is an Assistant Professor in the Joint Department of Biomedical Engineering at North Carolina State University and the University of North Carolina-Chapel Hill. After receiving a BS in Biomedical Engineering from Columbia University, he completed his PhD degree under the mentorship of Dr. Savio L-Y. Woo at the University of Pittsburgh. His dissertation research focused on the use of extracellular matrix bioscaffolds for anterior cruciate ligament healing as well as the use of robotic testing systems for biomechanical evaluation. He then moved to the University of Pennsylvania as a post-doctoral fellow under the mentorship of Dr. Robert Mauck. At Penn, his work focused on tissue engineering of the knee meniscus and articular cartilage, with a focus on implementation in large animal models.

Since 2014, Dr. Fisher has directed the Translational Orthopaedic Research Laboratory. Through a team science approach, Dr. Fisher and colleagues have 1) advanced the understanding of anterior cruciate ligament function during growth, 2) designed scaffold fabrication approaches for fibrous tissue engineering, and 3) developed translational animal models to study biomechanics of healing and engineered tissues. Dr. Fisher has published more than 40 peer-reviewed journal articles and more than 100 conference abstracts. His team's research has been supported by the NIH, NSF, and several research foundations. He is thankful to have interacted with truly remarkable



people in the laboratory, classroom, and community, including many years at the ASME Summer Bioengineering Conference and SB<sup>3</sup>C meeting. Dr. Fisher has been a member of ASME since 2008 and has been active in the Bioengineering Division since then. He is the recipient of the 2012 Junior Investigator Award from the Musculoskeletal Transplant Foundation and a 2020 Rising Star Awardee from the BMES Cellular and Molecular Bioengineering Special Interest Group. He lives happily in Apex, NC with his wife and two young children.



## Award Lecture Abstracts

**Wednesday, June 17, 2020**

Matthew B. Fisher, *Y. C. Fung Early Career Award*

Title: Anterior Cruciate Ligament Function During Growth

The anterior cruciate ligament (ACL) is a primary soft tissue stabilizer of the knee. ACL injuries are rising in children and adolescents, with many undergoing surgical treatment. Yet, changes within the ACL during growth, including biomechanical properties, are less understood. Over the past few years, we have studied how age and sex impact the biomechanics of the ACL and its distinct sub-regions using a large animal model. We have also explored the impact of complete and partial injuries on resulting joint function. As we continue to translate our findings to the human condition, we hope to inform clinical treatment strategies in the pediatric population.

Stavros Thomopoulos, *Van C. Mow Medal*

Title: The Attachment of Dissimilar Materials: Lessons from the Tendon Enthesis

The attachment of dissimilar materials is a major challenge because of stress concentrations that develop at such interfaces. An effective solution to this problem can be seen at the attachment of tendon to bone (the enthesis). This transitional tissue is not recreated during healing, so surgical reattachment of these two dissimilar tissues often fails. To develop strategies for tendon-to-bone repair, we are focusing on: (i) defining the design criteria for attachment by studying the multiscale load transfer mechanisms at the healthy enthesis, (ii) defining the roadmap for building an attachment by studying the signals necessary for forming a functional enthesis, (iii) implementing the design criteria and the roadmap using regenerative medicine, and (iv) testing these strategies in animal models. Basic science studies have identified the critical biomechanical and developmental features necessary for tendon-to-bone attachment. These results now inform translational studies using cell- and growth factor-based regeneration for tendon-to-bone repair.

**Thursday, June 18, 2020**

Mehmet Toner, *Savio L-Y. Woo Medal*

Title: My Journey in Bioengineering on the Shoulders of Early Visionaries

Dr. Toner will review some of his major research contributions to biomedical engineering. Dr. Toner's work in low temperature thermodynamics of cellular systems includes both fundamental and applied aspects of cryopreservation of cells, gametes, tissue constructs, engineered tissues, and whole organs. In tissue engineering, he developed cell patterning techniques to interrogate heterotypic and homotypic cell-cell communications. He also micro-engineered the complex topographical features of the skin. Dr. Toner led the development of a micro-engineered bioartificial liver system that overcomes the major transport-related shortcomings of the clinical bioartificial liver systems. His group was the first to use microfluidics to isolate extremely rare circulating tumor cells from peripheral blood with applications in personalized oncology. Dr. Toner has also pioneered using inertia in microfluidic systems by demonstrating that inertia is extremely useful and easily exploited in these systems to achieve amazing control over manipulation of bioparticles and cells.

Dawn M. Elliott, *Robert M. Nerem Education and Mentorship Medal*

Title: White Privilege and Racial Injustice: What a Person in the Academy Can Do

I tried. But I could not prepare a light-hearted retrospective of my career to date in the midst of what is happening in our country. What will I say about white privilege? What will I say about racial injustice? What can a person in the academy do? Today as I write this abstract I am uncomfortable and confused and so many other emotions that I have not processed. I do not know what I will say. By the time I give my talk, I will still be uncomfortable. But I will have something to say and a message that provides each of us a path to *do something*.



**Friday, June 19, 2020**

Larry Taber, *H. R. Lissner Medal*

Title: From Rockets to Embryos

The purpose of this talk is to discuss the winding road I have traveled during my career. (Apparently, this is the tradition for the Lissner Medal lecture.) So, I will spend some time documenting how my career ambitions evolved from baseball play-by-play announcer to meteorologist to designing manned spacecraft to working with embryos. Then, I will discuss some of work that my lab has conducted on the mechanics of organ morphogenesis during the past 20+ years. Our research has involved a combination of experiments and computational modeling. The focus will be on heart, brain, and eye development.

## 4 Reviewers

**The SB<sup>3</sup>C Conference and Program Committees thank all of our abstract reviewers!**

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## 5 In Memorium

# Yuan-Cheng “Bert” Fung, Ph.D. September 15, 1919 – December 15, 2019

The Father of Modern Biomechanics  
and  
a 5G Man  
(*Genius, Giant, Generous, Genuine and Gentle*)

Written by:

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May 25, 2020 (Memorial Day)

At exactly three months after our Bioengineering Field celebrated Dr. Fung's centennial birthday, we lost our most recognized and respected pioneer on December 15, 2019! It is impossible to do justice to memorialize Dr. Fung's long, productive and impactful life on all of us. Thus, this writer would encourage everyone to read those articles on the reference list in order to get to know more about Dr. Fung [1-4]. Briefly, Dr. Fung was known as a pioneer and brilliant researcher, a distinguished scholar and consummate teacher, a quintessential leader and visionary role model and above all, a respected mentor and cherished friend. The writer suggests that we might all want to remember him in the following way.

Fung was a Genius! With his visionary thinking and thorough understanding of the laws of physics as well as mastery of applied mathematics, Fung made seminal contributions in both Aeroelasticity and Biomechanics. With his distinct and clear writing skills, he taught us lessons on the sphering of red cells, sheet flow for pulmonary alveolar microcirculation, strain energy density function for living soft tissues, quasi-linear viscoelastic theory for soft tissues, stress-dependent homeostasis as well as residual stress and wave propagation to reduce impact trauma and so much more.

Fung was a Giant! He was elected to all three U.S. National Academies (Engineering, Science and Medicine) and also the Chinese Academy of Engineering and Academia Sinica. He received a National Medal of Science from President Clinton and also won the Founders Award and Russ Prize from the National Academy of Engineering. The International Astronomical Union named an Asteroid (210434 Fungyuancheng) after him. Our distinguished colleague, Shu Chien wrote that "Dr. Fung opened up a new vista for bioengineering... Dr. Fung is not only a superb scientist and engineer, but also a wonderful artist. He has excellent command in Chinese calligraphy and poetry. He is a Renaissance man" [2].



Fung was Generous! He loved to share his vast knowledge freely and his time with all his students, colleagues and friends. He had written many outstanding treatises in Applied Mechanics and Biomechanics. He was personable and easily approachable to all and was very liberal with his time to dispense his advice. He also devoted his best efforts

toward his profession and its promotion. The ASME Biomechanics Symposium (the predecessor of our SB<sup>3</sup>C), the World Congress of Biomechanics, the U.S. National Committee of Biomechanics and our Journal of Biomechanical Engineering were all started by Fung. He also taught many of us the needed steps to do research properly.

Fung was Genuine! Those of us who are lucky enough to know him well will always remember him fondly in that way! Geert Schmid-Schoenbein, one of Fung's mentees from UCSD said, "He was the most joyful individual. When you stepped into a building, you could tell where he was just by the sound of his laughter" [5]. Mike Yen, another mentee, accompanied Fung on a trip to China after the Cultural Revolution and Yen said, "Everywhere we went, he wanted to help the poor and the needy. I learned from him to be concerned about people's humanity" [5].

Fung was Gentle! Many have fondly called Fung "a gentleman and a scholar". Pin Tong, his mentee said, that "he believes in harmony and gentility. He treats everyone collegially and does not compete with anyone" [4]. Ghassan Kassab, another mentee, has written a beautiful article on Fung [6]. When reading it, one would learn what a gentle professor Fung was. Peter Chen, his student and colleague said that "Fung treats his students like family and takes care of all their needs. As such, students could focus on their studies while learning to respect, admire, and love him" [7]. Below is one of the treasured notes Dr. Fung had written to me in 2011 [3]:

*"... it has been such a joy to be your friend and colleague for such a long time - a combined 82 years if we count in both directions - and to see your career and family blossom. Our scientific discoveries during our long collaboration, and your pioneering work in the years since, have accumulated to an extraordinary contribution to humanity. Each discovery, and each interaction, has been personally satisfying. The personal connection is most precious. How rare is the chance to combine work and friendship, so deeply, and for so long! We have been blessed with more than our share of harmony and opportunities. Living close by for 20 years enabled our families to become fast friends, and bioengineering conference organizers pick such great venues that our community has remained close for decades since." Luna, Dr. Fung's beloved wife and partner for almost 70 years shared: "He laughs frequently and heartily. He loves deeply. He loves his family. He loves his friends. He lives simply. He does not demand anything. He does not compete with anyone and never tries to keep up with the Jones" [8].*

Conrad and Brenda took great care of their parents for a number of years. They revealed ten years ago that "...our father's diary, a personal record begun in school three quarter of a century ago and updated daily ever since ... intervening days number over twenty-seven thousand ... feelings were recorded, as were guest lists of innumerable parties... . 'What dedication,' we once wondered aloud in his presence, to which he replied, 'I decided to do it, and I did it' " [9]. They also wrote, "To understand our father's inner harmony and how he could achieve so much with such apparent ease, we cite one of his favorite sayings. 'Easy to do. Hard to Know,' as a unifying theme for his life as a model of Choice coupled with Commitment" [9]. Dr. Fung is survived by Conrad A. Fung and Brenda Fung Manos and three grandsons, Nicholas Manos (wife Claire Bazley), Anthony Fung and Michael Fung.

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## Robert M. Nerem, Ph.D. July 20, 1937 – March 6, 2020

Written by:

C. Ross Ethier, Ph.D.

Professor

Georgia Research Alliance Lawrence L. Gellerstedt, Jr. Eminent Scholar in Bioengineering

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May 18, 2020

Our community lost a founding member with the passing of Robert (“Bob”) Nerem in Atlanta on March 6, 2020. Like many biomechanical engineers of his generation, Bob began his academic career in a traditional engineering field (in his case, as an aeronautical engineer), graduating in 1959 from the University of Oklahoma with a B.S. degree and in 1964 from The Ohio State University with his Ph.D. His research started out in the area of hypersonic flow and heat transfer, but took a fortuitous detour into biomechanics through a project with NASA. This piqued his interest, and to advance his knowledge in this relatively new field he spent a sabbatical in 1970 at Imperial College of Science and Technology, in London. This converted him into a biomedical engineer, a field he worked in for the rest of his remarkable career.

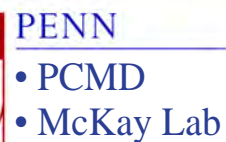
In 1979, Bob moved to the University of Houston to take up the role of Chairman of the Department of Mechanical Engineering, and then moved to Georgia Tech in 1987. His productivity was remarkable, and in recognition of his impact and stature he received many accolades, including three honorary degrees. Further, he was elected to both the National Academy of Engineering and the National Academy of Medicine; was a Foreign Member of the Polish Academy of Sciences, a Fellow of the American Academy of Arts and Sciences, a Foreign Member of the Royal Swedish Academy of Engineering Sciences, and a Honorary Member of ASME. He sat on nearly 30 advisory boards. Relevant to our community, Bob chaired the Bioengineering Division of ASME, chaired the ASME Board of Editors, and served the ASME Journal of Biomechanical Engineering for many years, first as Associate Editor (1977 – 1983) and then as Technical Editor (1988-1997). He also served on the editorial boards of 9 other journals. He sat on the Board of BMES, was the Founding President of both the International Academy for Medical and Biological Engineering (IAMBE) and the American Institute for Medical and Biological Engineering (AIMBE), was a co-founder of Tissue Engineering and Regenerative Medicine International Society (TERMIS), President of the International Federation for Medical and Biological Engineering, President of the International Union for Physical and Engineering Sciences in Medicine, Chair of the National Academy of Engineering Bioengineering Section, Chair of the U. S. National Committee on Biomechanics, and a member of the World Council on Biomechanics. One of the achievements that he was most proud of was co-founding Project ENGAGES, a program that provides a full year research experience for African-American high school students from Atlanta Public Schools.



Many of us were fortunate to know Bob personally. He always had a wise word for colleagues, and was endlessly supportive of our community. In recognition of his remarkable work, the Bioengineering Division of ASME recently established the Robert M. Nerem Education and Mentorship Medal.

A fuller accounting of the professional life of Bob Nerem has been published in ASME J Biomechanical Engineering (Ethier et al., “In Memoriam Robert M. Nerem, 1937-2020”, Vol. 142, article 060101, 2020. <https://doi.org/10.1115/1.4046990>).

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