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Guest Editorial

2020 Timoshenko Medal Acceptance Lecture: Mechanics: Evergreen and Forever New

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Dear Friends and Colleagues, and Our Extended and Extensive Mechanics Family:

Thank you.

I am deeply honored to be selected for this incredible recognition—the Timoshenko Medal. Wow, I have to catch my breath just at the thought. Everyone here today understands how meaningful this recognition is in our applied mechanics community, and there simply are no words to express my gratitude and appreciation. So, again, thank you.

The lists of Medalists stemming each year from 1957 are remarkable, each with significant, unique, and long-lasting contributions to mechanics. Through the years, so many Medalists have also shared the extraordinary personal histories that lead them on this path. It is truly humbling to be included in this historic cohort. While each Medalist is unique, shared among them is a common love and joy for the beauty, the elegance of applied mechanics—a joy that I share.

The contributions of Timoshenko himself exemplify this elegance where his classic texts have such clarity of thought—teaching each of us how to simplify the complexity of a structure or problem down to its most fundamental elements and then to crystallize a mathematical solution that provides a deep understanding of the physics together with a rational engineering solution for prediction and design. I think we all strive to have these signatures in our own work.

Today, we gather together virtually due to the unprecedented challenges of the global pandemic. I am thus challenged to be a "first", not just the first woman but also the first "virtual" Timoshenko Medalist. I so wish we were here to celebrate together, in person—I want to reach out to so many friends, students, collaborators, and colleagues since this medal also reflects their contributions. I hope to do so in person when possible.

Nonetheless, in this awkward remote mode, I will try to share some reflections on my own journey and on the importance of people along the way and also share some of my thoughts on our field and on embracing broader leadership roles.

First, some reflections on my journey: As I read the extraordinary paths of so many Medalists, I feel particularly humbled by how my "ordinary" upbringing lead me to this extraordinary academic journey. However, at the same time, I recognize that no path is ordinary—each has its own twists and turns—and mine has been so fortunate.

My story is an American story. All of my grandparents immigrated to the US from Ireland, without resources and with far less than a high school education. My grandparents met one another here in New York City. I look back and imagine how courageous this path in life was for each of them. I have the original ocean-going travel trunk of one of my grandmothers, Mary Ann Dowling, emblazoned with her initials M.A.D.—what great initials!

I know from many stories how hard they worked for their families, how they valued education, and how that has enabled my own, much easier journey in life. My dad was then the first to graduate from college after serving in the Marines and built a successful career as a businessman in a major corporation. I am one of seven children and my parents provided us with a wonderful life. They valued our family, our education, hard work and perseverance, our independence, and our happiness; they also valued the fact that we are each so different from one another. I am so fortunate for my parents and my siblings, and I share these values. These values enabled me to be myself, to find and pursue my interests, no matter how challenging or different.

It was my interest and actual joy of mathematics in elementary school through high school, from geometry to algebra to calculus, that began my academic journey. Physics in my senior year then clinched this interest where the combination of Mathematics together with Physics to understand and explain so much of our world was fascinating. I was so fortunate to have teachers throughout elementary, middle school, and high school who recognized my interests, encouraged me, and really inspired my love of these fields.

Of course, as I prepared for college, I then thought I should become a physicist but learned about this more practical, tangible field of "engineering." Off to Virginia Tech to study "engineering"—it took me a while to find the right engineering match for me. I co-op'ed at different companies to learn "what do engineers really do?". I discovered, through these experiences and through great faculty, that I could actually major in Engineering Mechanics, combining my love of mathematics and physics very directly with engineering!

I had wonderful mentors throughout my time at VA Tech—Wally Peters, Michael Hyer, J.N. Reddy, Robert Heller and Bill Saric, to name a few. As an undergraduate, I was also able to participate in independent research projects (one on composite materials and one on finite element analysis). For me, it was so important and intellectually shaping to be part of the exciting frontiers of a field. This was a critical part of my decision to later pursue graduate school and is something that I have encouraged and supported for undergraduates throughout my time as a faculty member.

On reflection, these experiences also underscore how influential a teacher or faculty member can be on a student's trajectory. I have been so fortunate. Several medalists have commented on the importance of inspiring teachers or experiences in their Medalist Speech. In 1962, Biot indicated "One of the important functions of a school is to discover, encourage and develop talent"—a great message for all of us in academia.

I then went into the aerospace industry as an engineer where I worked on modeling composite materials and structures, and I also met my husband! I quickly came to realize that my real interest was on the research side of engineering—so back to university and the beginning of my graduate days at MIT.

At MIT, you were encouraged to quickly find a research match and faculty advisor. Again, I was fortunate. Ali Argon was bringing mechanics thinking to collaborations around polymeric materials toughened by microscopic composite rubbery-like particles. It seems as though, right from the start, I was in weekly or biweekly research meetings with Ali Argon, David Parks, and Bob Cohen … and me. Not knowing any better, I thought this was quite normal. Looking back, it is rather astonishing the time, mentoring, and advice that I received—from three very different perspectives. It opened my eyes to the power of interdisciplinary thought and collaborations, and diving deeply into very different fields in order to advance your own field. Their styles also showed me how to engage, nurture, and mentor your students and postdocs and to always give them room to explore.

I continued in this interdisciplinary spirit as I shifted into the highly nonlinear finite deformation elastic-viscoplastic behavior of glassy polymers for my Ph.D.—deep mathematical formulations together with molecular physics together with computational mechanics—so much to learn, so much to develop, and so much to integrate together—I loved it! The announcement for my MIT faculty interview seminar when typed up somehow got announced as "Finite Deformation Elastic-Viscoplastic Behavior of Classy Polymers"! My Ph.D. years were an amazing time for me intellectually and I am so grateful, particularly to David Parks and Ali Argon, who constantly encouraged physical insight and simplification together with the precision of mechanics.

I also had incredible and brilliant student peers, and many of us have remained connected across our careers. One cannot underestimate the engagements and interactions with your peers in this environment. You are pushed to learn deeply and to see things from many perspectives. They also bring levity and joy to the days when you are toiling away on a challenging derivation, code, experiment, or problem that just won't work out—very special bonds are formed that are unique to that intense period.

During this time of our graduate days, we are also positioned to experience how these academic pursuits bring together brilliant talent from across the country and around the world. As in many science and engineering fields, we had a very international group with students and postdocs from across the United States as well as from Russia, Greece, France, Italy, Turkey, India, Japan, Korea, Morocco, and Argentina, and students from China were just beginning to come to study in the United States, and the number of countries represented continued to expand with each year. This experience made me to appreciate the importance and richness of a global community. It is inspiring how scientific and engineering research can bring so many together in shared interests and pursuits—we learned so much from each other and in so many ways.

Upon graduation, I was again fortunate—this time to join the faculty of MIT. I had also just had my first child and began the difficult balancing act of family and an intense academic career! My mechanics advisors, now turned colleagues—David Parks, Ali Argon, Frank McClintock, Stan Backer, Michael Cleary, Lallit Anand, and later joined by Rohan Abeyaratne and Subra Suresh —enabled an intellectually rich environment. A major focus across the group was the mechanics of materials—in particular nonlinear mechanics and expanding mechanics to discover and understand the connections between microstructure and nonlinear material behavior. I deepened my interdisciplinary collaborations and connections particularly with materials science and chemical engineering—Bob Cohen, Ned Thomas, Christine Ortiz, Greg Rutledge, Karen Gleason, Lorna Gibson, and so many others. My group has explored and expanded into so many areas over the years while also maintaining a primary focus on the molecular and microscale structure of polymers, soft materials, micro-composites, and nano-composites. This also lead to a focus around natural/biological materials and bio-inspired materials design. I was also fortunate to have research consulting projects with materials groups at different companies that also influenced my perspectives and thinking.

I continue to be excited about the amazing molecular scale chemistry to nano- and micro-scale geometric designs that enable tailoring nonlinear, time- and temperature-dependent behavior, pattern transforming and morphing materials, and so much more—these open up new avenues in mechanics and new avenues in materials and device design. This field remains incredibly exciting with so many opportunities ripe for exploration—it is an amazing time to be a mechanician!

One of the most rewarding aspects of being an "academic" is that we have the privilege to be continually renewed, challenged, and inspired by not only our colleagues and peers but also by our students and postdocs. I have, once again, been fortunate. My doctoral students and postdocs are at the core of my contributions and achievements to our field. More importantly, I consider they themselves to be a key contribution to the field and to the next generations of students. They enabled me to explore new frontiers through their work. I have learned so much from each of them—their curiosity, drive, intellectually adventurous attitude to explore and design and their creativity and courage to move into whole new areas while attending to the beauty and depth of mechanics. I have a deep inner pride in their ongoing contributions and successes.

Advising my students and postdocs also helped unburden me from "overthinking" the complexity of the mechanics—to work to bring clarity and simplicity to a challenging problem in order to understand and explain to others, while respecting the precision of mechanics—a signature of Timoshenko! This is so critical to enabling creativity in our field.

I have also been so pleased by the international diversity and the gender diversity of my group over the years, and their collaborative spirit and support. Many from my group have gone on to faculty positions in the United States and around the world, providing their own independent scholarly contributions and also inspiring the next generation of talent. I expect to see at least one of this amazing cohort as a Medalist in the future!

Let me reflect a little further on our field: Our remarkable field, applied mechanics, was in earlier days characterized as "mechanics, physics and applied mathematics" and today also clearly incorporates chemistry, biology, and more.

In my view, mechanics never grows old; it is evergreen while also forever new and changing, yet rarely flashy. Biot, in 1962, indicated "modern engineering by its very nature must be synthetic"—this statement captures the very essence of the interdisciplinarity of engineering and, indeed, of applied mechanics. This synthesis, this interdisciplinarity, enables the exciting frontiers in mechanics today.

Mechanics continues to guide and drive breakthrough advances in vehicles (auto, aero, space, shipping, rail, drones), structures (buildings, bridges, roads), robotics and devices, manufacturing processes, energy, materials, and even electronics. So much can be said on the role of mechanics in the frontiers of each of these areas. Here, let me comment very briefly only on some of the exciting areas in mechanics of materials.

Advanced materials are truly a frontier with rapid developments—mechanics is at the forefront of these developments. Our ability to model, compute, build, and characterize over multiple lengthscales from the atomic to the nano to the micro to the macro is a reality that is ready to be harnessed. The capabilities and tools are so rapidly developing, and it is exciting and challenging to keep up with the pace of these developments. These frontiers are highly interdisciplinary, and there is increasing need to embrace collaborative research. This opens new frontiers in multifunctional materials design and the need to develop the highly coupled mechanics to understand, predict, and truly design these materials. Materials that are active and responsive, materials that transform and morph in structure and function—the molecular structure, the microgeometry—all open new frontiers. The material itself becomes the device, enabling soft robotics and actuators, responsive surfaces, and even morphing vehicles. We are inspired by natural creatures and structures—from the camouflage of sea creatures with changing color and surface topographies, to antifouling surfaces and switchable adhesion, to self-healing microstructures that recover from extreme damage, to the biological processes of biomolecules, cells and tissues, and so much more. Advancements in computational simulation techniques enable multiscale modeling and optimization, advancements in precision measurements and imaging, from the nanoscale to the macroscale, enable real-time and three-dimensional assessment of properties and functions, artificial intelligence will combine with physics/chemistry/mechanics-based simulation to drive rapid discovery of materials and devices, and accurate predictions of large scale, coupled phenomena.

Mechanics is an exciting frontier. Indeed, applied mechanics transcends so many fields and draws from being evergreen on the one hand and yet forever new and advancing on the other, further buoyed by the curiosity, creativity, and sophistication of mechanicians!

Let me close by reflecting on broader leadership roles: I am, at heart, an engineer and an applied mechanician. My curiosity in understanding the structure, properties and function of a material, a structure, a process, or a creature feels inherent. The intellectual challenge to simplify, to model, to predict, to design, to discover is exciting. I have been so fortunate and privileged to be part of this field and part of mentoring so many who continue in this field, particularly with the breakthroughs on our horizon. It has also made me recognize the broad intellectual impact is not only on the scholarly field but also on attracting and nurturing the talent that defines the field.

The twists and turns of the "leadership" elements of my career (beyond scholarly aspects) were initially highly scholarly in nature through developing and leading multi-disciplinary, multi-investigator research which amplified my own research interests, and then onto leading mechanical engineering.

The major opportunity to lead the expansion of the School of Engineering and Applied Science at Columbia University (itself with its own rich history in applied mechanics) has led me to be able to further expand the cross-disciplinary role of *engineering* as a foundational field that now transcends in a deep way into impact on "non-traditional" partner disciplines. So many in our younger generation, now see the foundational nature of engineering as a critical part of their education, together with the liberal arts, and brings a wider perspective and talent pool to how engineering will shape so much of our future. As we work on the many challenges confronting our world today and know the positive impact that engineering can bring, it is exciting to be a small part of leading this broader expansion of engineering and propelling the talent needed for the future.

Finally, I began with a brief comment on my family—my grandparents, my parents, and my siblings. Let me finish with an appreciation of my husband of 37 years and our two grown sons, who are each so different and always fill me with pride and joy—the greatest and most significant part of my life.

Thank you all again for this recognition and honor.

With my deepest gratitude and respect,

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