

Biomechanics: Celebrating Contributions of Y.C. Fung

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Professor Yuan-Cheng Fung is widely recognized as the father of the modern field of biomechanics – that is, the development, extension, and application of principles and concepts of mechanics to study problems of biology, physiology, and medicine. His contributions, both technically and professionally, are manifold and have been recognized by countless awards and honors, including election to all three National Academies within the USA (Engineering, Medicine, and Science) and receipt of the Russ Prize and the National Medal of Science. His graciousness encouraged many colleagues and young investigators; his energy and vision led to the creation of new journals, societies, professional meetings, and increased international cooperation; his scholarship yielded many fundamental books, including a series of three on aeroelasticity and foundations of solid mechanics (Fung, 1955; Fung, 1965; Fung, 1969) and a series of three on biomechanics (Fung, 1981; Fung, 1984; Fung, 1990); importantly, his science impacted and continues to direct our understanding of multiple physiological systems. It is thus an honor to celebrate the 100th year since his birth in September of 1919.

At the age of 75, Professor Emeritus Fung reflected on his personal experiences (Fung, 1994), stating that they have nothing to do with one's science, but they have "a lot to do with one's choice of topics and the approach one takes." Professor Fung entered college in 1937 in China and "chose to study airplane design because that seemed to be needed most by China to fight for its survival." His first technical paper was published (in Chinese) in 1944 on "Gliding and Soaring in the Clouds." He subsequently moved to the USA and obtained a Ph.D. in aeronautics and mathematics at Cal Tech (1948), where he remained on the faculty until 1966 when he moved to UCSD to focus his research, scholarship, and leadership on physiology and bioengineering. This move, at age 47, initiated a new career that had immediate, far-reaching, and lasting impact by defining and directing a new field.

Although his move to UCSD in 1966 signaled his full devotion to bioengineering studies, his interest in physiology actually began in 1957 when his mother was diagnosed with glaucoma. He thus used much of his 1957-1958 sabbatical in Europe to begin his self-study of physiology. His first papers on biomechanics did not appear until 1966, however, including one in *Circulation Research*, with B. Zweifach and M. Intaglietta, on the microcirculation and one in *Federation Proceedings* on red blood cell elasticity.

One of his first seminal papers introduced the concept of "sheet flow" within aveolar walls in the lung, the first full theoretical paper on which appeared in 1969 in *American Journal of Physiology*. This work initiated what would be a rewarding 10+ year study of blood pressure-flow relationships in the lung, which also led to allied studies of the elasticity of lung parenchyma and remodeling of pulmonary arteries. Additionally, Professor Fung suggested that this study led him to develop a "master plan" for attacking problems in biomechanics, one that allowed him as well as his colleagues to advance our understanding of many other aspects of biomechanics, as detailed in his books (Fung, 1981, 1984, 1990).

In particular, he wrote (Fung, 1994) that this master plan "begins with morphometry, centers on the determination of the mechanical properties of materials involved, then follows a process of formulating boundary-value problems based on well accepted basic principles, solving the problems and testing the results experimentally in order to validate the analysis and gain confidence in the results, until it becomes possible to put all the blocks together..." Importantly, it was this plan that led to many other advances by Professor Fung and his colleagues, including the concept of pseudoelasticity, exponential strain-energy function, importance of residual stress in tissues, and role of mass-stress relations in biological growth and remodeling. Finally, it is noted that he wrote that "we had lots of fun on the way", consistent with his foreword in 2002 to the inaugural issue of the journal *Biomechanics and Modeling in Mechanobiology* wherein he wrote "let us enjoy the work". Clearly, we should go and try to do likewise while following the incredible example of scholarship and dedication to discovery that characterizes Professor Y.C. Fung, whom we celebrate at this time.

Acknowledgments: I was unusually fortunate to meet Professor Fung in 1979 when he gave a seminar at Virginia Tech; I was only a sophomore with growing interest in biomechanics, but was asked by the hosting faculty member (D. Vawter, a former Ph.D. student of Professor Fung), to attend the faculty dinner celebrating the visit. I later attended Professor Fung's 65th birthday celebration at La Jolla (1984) while a graduate student, and thereafter enjoyed numerous conversations with him, both at technical meetings and during many visits to UCSD. I was thus incredibly honored to receive the Y.C. Fung Young Investigator Award from ASME in 1990. As a token of my appreciation and esteem, I dedicated to Professor Fung a 162-page review article "Arterial Wall Mechanics: Review and Directions" that appeared in 1995, after which he wrote me a wonderful letter that I continue to treasure – another example of his gracious encouragement.

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