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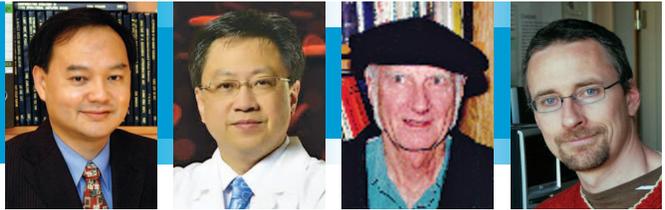


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From the Guest Editors



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The Third Revolution in Medicine—the Convergence of Life Sciences with Physical Sciences, Mathematics, and *ENGINEERING*

Alvin Toffler, a writer and futurist in the 1960s, described in his book, *The Third Wave*, the concept of ‘waves’ to describe society where each new wave replaces the old wave—pushing the older society and cultures aside. He viewed the First Wave as the society after the Agrarian revolution, replacing the hunter-gatherer cultures. The Second Wave was the society during the Industrial Revolution (17th–mid-20th century). The Third Wave is the post-industrial society (from late 1950s), which he coined as the super-industrial society. Many have otherwise named this Third Wave as the Information Age, Space Age, Electronic Era, Global Village, Technetronic Age, Scientific-technological Revolution age, etc. The commonality amongst these names is electronics, computing, and communication—the last half of the 20th century ‘belonged’ to electronics, computing, and communication, perhaps best exemplified by the activities of the IEEE.

Within the societal Third Wave era, most of us have enjoyed the digital electronics revolution, also often described by three ‘digital’ waves. Commencing with the first digital wave, this is the mainframe computer era from the 1970s to the mid-1980s, where the number of people actually working with technology was small. The second digital wave, sometimes called the PC ‘hooked

to servers’ era from the mid-1980s to the late 1990s was more exciting and the number of people involved with technology multiplied immensely. We are now deep in the third digital wave from the onset of the 21st century (from 2000) where digital technology touches everyone and everything—technology is pervasive, ubiquitous, and connected to the Internet.

Perhaps not as much appreciated or discussed within the IEEE is that medicine has also undergone its waves of technological revolution. Following molecular biology contributions in the 1970s and the much-hyped human genome project in the 1990s, we are now in the era of the ‘Third Revolution in Medicine’—the convergence of life sciences with physical sciences, mathematics, and *engineering* (including the EE fraternity and the IEEE). Just as the old wave recedes and new wave accretes as part of the progress of humanity, the old wave (the last half of the 20th century belonging to electronics, computing, and communication) is being ‘replaced’ by the new wave—the first half of the 21st century belongs to biology. This raises the question, “Are the EE fraternity and the IEEE prepared for this Third Revolution in Medicine and the Century of Biology?”

This special issue of the *IEEE CAS Magazine*, co-organized by the LiSSA and BioCAS technical committees of the Circuits and Systems (CAS) Society, aims to discuss this question and seeks the opinion of renowned experts and researchers from various establishments and backgrounds, including a researcher who

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is both an EE engineer and an MD. The short answer, arguably and contentiously, is that the EE community and IEEE are somewhat unprepared but are cognizant and increasingly aligning their activities to be pertinent to the Century of Biology.

This special issue was first mooted at the 2011 IEEE-NIH LiSSA (IEEE-National Institutes of Health Life Sciences Systems and Applications) workshop—the only (series of) IEEE-related workshop(s) that is held within the NIH campus in Bethesda; we will later articulate why it is important for an IEEE-type workshop to be held in the NIH campus. This objective of the workshop is true to the Third Revolution in Medicine—an initiative supported by NIH through a conference grant to Prof. Stephen Wong, one of the guest editors and a member of the LiSSA technical committee, to facilitate dialogue between engineering (IEEE) and biomedical/life sciences communities—to encourage symbiotic multi-disciplinary research between the two diverse communities. This is perhaps the ‘perfect match’ between the engineering technology push and clinical pull—a ‘sweet spot.’

We are very pleased that this special issue embodies five highly readable, interesting, and diverse articles. The first article, entitled “Opportunities in the Life Sciences” is authored by Mathukumalli Vidyasagar (Sagar), the inaugural chair of the IEEE Life Science Committee. In this article, Sagar informs that the IEEE is fully cognizant that the first half of the 21st century belongs to Biology, perhaps exemplified by the fact that NIH’s funding is \$32B versus NSF’s (National Science Foundation) \$6.9B—nearly 5x (or in engineering terms, a substantial ~14 dB higher)! Also, as the academic life sciences community is much larger than the academic electrical engineering community, he urges “...the imperative for EEs to reach out to life scientists is larger than the other way around...”—the reason why the IEEE-NIH LiSSA workshops are held on the NIH campus. IEEE is, in some sense, indeed active with as many as 30 technical committees (the CAS society has the BioCAS and the LiSSA technical committees, and organizes the LiSSA workshop, BioCAS conference and the CASME (CAS Medical and Environmental) workshop) dealing with life sciences-related matters. Sagar concludes his article with a message for us (IEEE members), “...the EE community has to go more than 50% down the road in order to establish links with

the life sciences community” and encourages us with “...the returns would be well worth the effort.”

The second article entitled, “Promoting Innovation and Convergence in Military Medicine,” is authored by Warren Grundfest, Eva Lai, Charles Peterson and Karl Friedl from TATRC (Telemedicine and Advanced Technology Research Center), USA. The aforesaid authors, with a good mix of PhDs and MDs, articulate that ‘traditional’ research centers that operate within accepted processes and conventions are largely incompatible with innovations that tend to occur in less constrained, less conventional, and less risk-adverse environments; within our EE fraternity, we could perhaps ask, “Does this resemble EE research centers?” Put differently, the management objective at TATRC is to advocate and accelerate technology development and ensure beneficial implementation in the shortest time. The authors explain how TATRC accomplishes this through integrating multidisciplinary teams that combine engineering technology and physical sciences with both basic and applied clinical biosciences to solve medical problems—congruous with the Third Revolution of Medicine.

David Balshaw, a Program Director from the National Institute of Environmental Sciences (NIEHS), authored the third article entitled, “Engineering Circuits and Systems at the Interface of Environment and Health.” Amongst the twenty-seven NIH institutes and centers, NIEHS is the only NIH institute dedicated to reduce the burden of human illness and dysfunction from environmental causes by defining how environmental exposures, genetic susceptibility, and age interact to affect an individual’s health—an integral part of medicine. This interesting article explains the role of the exposure of chemicals in the environment to health, and poses ‘challenges’ akin to ‘Open Problems’ to the IEEE community. We are grateful to David’s kind gesture as a life scientist ‘reaching out’ to the engineering community just as Sagar urges the converse—thank you, David—and for his posing the challenges in a language that engineers can easily appreciate and comprehend, and perhaps immediately commence work!

The fourth article entitled, “AIMBE’s Role in Promoting Biomedical Engineering Input to Public Policy,” from the American Institute of Medical and Biological Engineering (AIMBE) is authored by Warren Grundfest, Jennifer Ayers, Sean Gallagher, Laith Abu-Taleb, and John Watson.

In this article, the authors explain that the purpose of AIMBE is to provide leadership and advocacy in the field of medical and biological engineering for the benefit of society. Most IEEE members are probably incognizant of the functions of such institutes, including its role in discussions regarding public policy and the public funding of biomedical engineering research—for the benefit of the entire ecosystem including patients, doctors, and the entire medical and biological engineering community.

The last article concludes this special issue with a Personal Perspective from a Circuits and Systems Engineer-Physician, Tam Nguyen. Tam has a highly unusual background—he received his BS and MSE degrees in EE, and whilst pursuing his PhD, he decided instead to acquire an MD degree. After completing his ensuing residency and fellowship (he is an Otolaryngologist and a fellow of the American College of Surgeons), he is now again pursuing his PhD in EE. Given Tam’s unique background, he is probably one of the select few MDs who actually appreciate what goes into the gizmos in medicine and in the operating theater—and probably one who can also repair and improve on them. If you have

the opportunity to speak to Tam, he speaks of ‘avant-garde’ medical devices such as implants—depicting his appreciation of the convergence of life sciences with physical sciences, mathematics, and engineering. His article makes good reading and suggests that engineers need to ‘get out of their comfort zone’ to enable revolutionary (vis-à-vis evolutionary) research, largely the same message that Sagar articulates, “... the imperative for EEs to reach out to life scientists”

Reaching out to the life science community can be challenging but rewarding. If you get the opportunity to participate in the 2013 IEEE-NIH LiSSA workshop, be prepared to listen to the foreign language of the life science research community. The BioCAS conference is also interesting with a larger circuits and systems perspective and the CASME workshop has an added environmental twist.

We greatly appreciate and applaud the effort undertaken by the authors of the five highly interesting articles. These articles make very good reading and we welcome and encourage you to the ‘Third Revolution in Medicine’—be part of the 21st Century of Biology!



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