What Does the Future Hold, and What Will Be Our Role in It?

Valerie E. Martindale, Ph.D., CAsP, FAsMA

It has been a privilege to communicate with you in these columns, and to spark some comment and conversation. One reader suggested that I write a column about the future of the organization. It seemed a daunting assignment, full of if's and maybe's, but once I got started, I found I had a lot to say. What follows is my view, informed and limited, no doubt in equal measure, by how I see the world. I hope it inspires you to follow the same thought experiment. We need all of you to navigate the future, that frontier that is never more than a moment away and stretches on forever.

First the trends that are driving the present into the future at high speed. Moore's "law" continues to hold, against even expert expectation.[4,9] There is no doubt that this has driven other trends, enabling computational mathematics, modeling and simulation, and the accumulation and manipulation of the enormous amounts of data generated by the study of complex biological systems. The ability to sequence the DNA of an individual human is now a simplistic example. The first human genome sequence (really a composite of five) cost US$3 billion and took more than a decade of work by multiple teams in multiple nations. Today a better quality read, from an individual genome, can be had for $1000 in a little more than a day, and the limits have not been reached.[3,5] Our stunning computational power also feeds trends toward automation, autonomy, and artificial intelligence.[2] Self-driving cars presage self-flying aircraft;[1] automated decision-making algorithms will continue to change the face of medicine;[*] and the software to manage 3D printing will enable regeneration of limbs.[6]

The computing power that drives imaging and chemical analytic systems, systems biology, and exquisite sensors also enables developments in biology that are now making the perilous transition into medical practice: recognition, management, and harnessing of the multitude of fellow travelers that compose the microbiome; advances in stem cell biology; gene therapies and related approaches to infectious disease; subtle interactions of living biochemistry that drive immune responses; inklings of the basis of mental illnesses.

I told myself that I would save the headliner of commercial space until last, but I can't help myself: our expanding role in space is also a trend that feeds off of, and feeds into, the others.

An underappreciated trend is the increasing capability of new national players at the forefront of science. Information science has a low threshold for entry. Low and getting lower. Nations whose resource constraints have prevented them from building cyclotrons or space launch facilities will increasingly be able to bring to bear their human capital in the information sciences. This includes computing, software, mathematics, and the sciences that depend on them. Biology is increasingly an information science. Medicine is increasingly an information science. And every nation that invests in health and education will reap human capital, and be able to enter a virtuous circle.[**]

So what does all of this portend for us? Change, certainly, some definitely for the good, some ambiguous, some in need of careful management. Here is what I see ahead.

First, the new and ever-evolving technological environment will create new human environments for performance and exploration. There will be new displays to interpret and new controls to manage, so the sciences of human-machine interface will continue to be challenged. At the same time, autonomy will create a whole new class of human factors problems involving the ability to trust, predict, and adjust to the actions of automated systems. Human systems integration will have no shortage of needy applications, and the art of simulation will advance to the point of offering valuable predictive tools to practitioners in this area.

Medical advances have been lengthening not just life, but active, productive life, for some time.[7,8] We are now facing the consequences of aging, in a world where frailty is (this is good news even if it doesn't sound like it) the primary mode of death. I have no basis on which to predict that frailty will yield to scientific advances, other than the fact that money and minds are being put to work on its many facets every day. Articles on stem cells in the central nervous system are promising, but promises are cheap. In the meantime, aging passengers, aging aircrew, and aging controllers are a fact. Aerospace medicine and human performance sciences will continue to be called upon to accommodate the trend of aging.

I have written before about the future of gene therapy and its near-term impact on aerospace medicine. We can expect a similar course for gene therapy to that of laser eye surgery: as the risks become ever more predictable and manageable, the bar for conditions suitable for treatment will be lowered. Even more interesting are investigations into therapy based on understanding DNA and RNA pathways without affecting the genome itself, using

[*] The journal, *Artificial Intelligence in Medicine*, began publication in 1989.

[**] From businessdictionary.com, "Self-propagating advantageous situation in which a successful solution leads to more of a desired result or another success which generates still more desired results or successes in a chain."

DOI: https://doi.org/10.3357/AMHP.5PP.2018

CONTACT DETAILS:
Email: President@asma.org • **Web site:** www.asma.org • **Facebook:** Aerospace Medical Association • **Twitter:** @Aero_Med

PRESIDENT'S PAGE, *continued*

RNA editing, epigenetic editing, and systems biology approaches. Understanding how these therapies interact with human performance and with the demanding environments of aviation and space will fall to us.

Another fallout of genomic science coupled with computing power is personalized medicine, the idea that medical management can truly take into account the unique composition and history of every individual. This has exciting potential to increase human performance at all levels, improving baseline health, resistance to illness, recovery from injury, and adaptation to desired activities and exposures. More people will be able to fly than ever before.

And now the headliner that I foreshadowed earlier: commercial space. It is certainly the star for 2018, seeing the success of the Falcon Heavy and the even more spectacular landing of the booster rockets. There is much more to be done in the way of engineering and especially the energy expenditure to escape Earth's gravity, but the means to do so is becoming more widely distributed. I have no gift of prophesy and so many things can go wrong, but I am willing to place a bet that I will live to see a commercial manned space launch and recovery, sooner rather than later. The role for us in that will not be new. But it will be spectacular.

So what do we do now? Prepare with the best minds, the best education, reaching across these many fields of endeavor that must work together to progress into the future. Maintain high standards for scientific rigor. Contend with a previously overwhelming complexity of information. Seek out the synergy of interaction, crossing divides and pushing boundaries. Recruit continuously to keep our specialties infused with new ideas, recent discoveries, and vigor. Continue to be a multinational association of professionals unified by vision.

I return now to where I began, with my humble gratitude for the privilege of serving as President of the Aerospace Medical Association this past year. At the end of the Annual Scientific Meeting, I will pass the gavel to my worthy successor, Dr. Roland Vermeiren. I would say that I wish you all the best, but it sounds too much like parting. Instead, I will say that I look forward to a long association with you, navigating the future, which will always be the final frontier.

REFERENCES

1. Falk D. Self-flying planes may arrive sooner than you think. Here's why. NBC News. 12 Oct. 2017. [Accessed 18 March 2018]. Available from: https://www.nbcnews.com/mach/science/self-flying-planes-may-arrive-sooner-you-think-here-s-ncna809856.
2. Giles M. The race to power AI's silicon brains. MIT Technology Review. 20 Nov. 20 2017. [Accessed 18 March 2018]. Available from: https://www.technologyreview.com/s/609471/the-race-to-power-ais-silicon-brains/.
3. Herper M. Illumina promises to sequence human genome for $100 — but not quite yet. Forbes. Jan. 29, 2017.
4. Hsu J. CES 2018: Intel's 49-Qubit chip shoots for quantum supremacy. Jan. 2018. [Accessed 18 March 2018]. Available from: https://spectrum.ieee.org/tech-talk/computing/hardware/intels-49qubit-chip-aims-for-quantum-supremacy.
5. International Human Genome Sequencing Consortium. Initial sequencing and analysis of the human genome. Nature 2001; 409: 860–921.
6. Kang HW, Lee SJ, Ko IK, Kengla C, Yoo JJ, et al. A 3D bioprinting system to produce human-scale tissue constructs with structural integrity. Nat Biotechnol. 2016; 34(3):312–319.
7. United Nations Department of Economic and Social Affairs, Population Division. Living to Old Age: A New World Norm. No. 2104/5. New York: United Nations; Sept. 2014.
8. United Nations Department of Economic and Social Affairs, Population Division. Population Aging and Sustainable Development. No. 2017/1. New York: United Nations; June 2017.
9. Wikipedia. Moore's Law. [Accessed 18 March 2018]. Available from: https://en.wikipedia.org/wiki/Moore%27s_law.