A new era of healthcare

Innovations in medicine and technology are revolutionising medical research and patient care. Recent advances include a needle-free injection for monitoring and treating diabetes, a surgically-implanted device that reduces seizures, a bionic arm that is sensitive to touch and targeted cancer-killing drugs. Telehealth and telecare are also becoming important tools in providing healthcare to an increasingly ageing population and those with long-term conditions.
**Which recent innovation has made a significant impact on your field and why?**

Are there any upcoming technologies/medical breakthroughs that are expected to shape your discipline in the next year or two?

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**Dr Heather Carnahan**  
*(Memorial University of Newfoundland):*

The use of simulation – ranging from benchtop and virtual reality simulators to standardised patients – has become the norm for teaching clinical skills to healthcare providers. As a result of this, best practices are being developed within the context of educational research relating to how simulation-based education should be designed. Haptic research is now being integrated into the development of high tech simulators to make them more realistic and to allow for more effective transfer from practice on the simulators to learning about and treating real patients.

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**Harvey Jay Cohen, MD**  
*(American Federation for Aging Research):*

Looking at how ageing and geriatrics can benefit from technology, I see a number of exciting developments. One such area is tissue engineering; an important example of this is the creation of artificial blood vessels, a field that is being pioneered by, among others, Laura Niklason, MD, PhD, of Yale University. This work seeks to grow replacement blood vessels in the lab from patients’ own vascular cells. This helps patients (most of whom are older) who need bypass surgery but do not have enough of their own healthy vessels to create a graft. Work on removing senescent cells, which cause inflammation in the ageing body and can, in turn, cause cancer, is also promising.

Additionally, I see many great applications for assistive technology that could be transformative in ageing. Better vision and hearing, as well as technology in ‘smart homes’ can all help people with disabilities move around much more easily – these factors have the potential to make a huge difference in terms of mobility and health status.

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**Gretchen L Haas, PhD**  
*(Western Psychiatric Institute & Clinic/University of Pittsburgh Medical Center & the Veterans Affairs Pittsburgh Healthcare System):*

There is not one innovation alone, due to the complexity and breadth of research currently being carried out in mental health-related science. However, one recent innovation involves the application of brain–computer interfaces and computer-engineered machine learning to train the human brain to direct the actions of a robot via thought – what seems like a mental telepathy of sorts. This type of bioengineering not only opens the field to a range of new rehabilitative strategies and interventions to remediate the loss of motor function, but also provides a platform to demonstrate the plasticity of the adult human brain.

In addition, one rather astounding addition to the world of neuroimaging is a new technology called Clear Lipid-exchanged Anatomically Rigid Imaging/immunostaining-compatible Tissue Hydrogel (CLARITY). It can provide a transparent 3D picture of the post-mortem human brain but, unlike other post-mortem imaging, does not alter the structure of brain tissue. It can be applied to the full volume of post-mortem human brain or, at high resolution, used to image cells, and even proteins and genes. This technology will give neuroscientists the ability to zero-in on microstructural brain changes in neuropsychiatric disorders such as schizophrenia and autism, while at the same time enable the viewing of alterations in the circuitry of the brain at a more macro-structural level.

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**Dr Warren G Hill**  
*(Beth Israel Deaconess Medical Center & Harvard Medical School):*

I think the most exciting and amazing breakthrough on the horizon will be the use of optogenetics and expression of ‘designer receptors’ to study brain neurocircuits and the regulation of lower urinary tract function. These tools have only recently started to make inroads into our understanding of the neural regulation of body weight homeostasis and fuel metabolism. Through the use of transgenic, gene knockout, and Cre-dependent adeno-associated virus (AAV) viral approaches, it is possible to generate the expression of different light-sensitive rhodopsin proteins in specific neuronal subpopulations, thus allowing the use of lasers tuned to particular wavelengths to turn these neurons on and off. This offers powerful and exquisite control over the activity of specific neuronal populations in the brain and will revolutionise understanding of how micturition (or urination) is controlled. The promise of these new approaches will be to link the function of defined neural circuits in the pontine micturition centre (Barrington’s nucleus) and periaqueductal gray regions of the brain with specific voiding related behaviours and physiologic processes. A great video about this approach can be viewed on the Massachusetts Institute of Technology website at: http://video.mit.edu/watch/optogenetics-controlling-the-brain-with-light-7659.

At the Beth Israel Deaconess Medical Center, meanwhile, Drs Mark Zeidel and Brad Lowell are beginning a collaboration in which they hope to perform experiments in this area. While urinating may seem to us to be a simple activity that we perform several times a day, it involves highly complex sensory and motor pathways with both unconscious reflexes as well as conscious volitional control. These circuits interact with our higher functioning brain centres so that we know when to hang on and when it is socially acceptable or ‘safe’ to go. Although most of us can control the urge if it occurs at an inconvenient time, those with urge incontinence and/or bladder overactivity feel an intense and overwhelming need to go on a far more frequent basis than they should. Neural mapping should begin to unravel both the normal wiring/firing diagram, as well as prove amenable to seeing what may be amiss with animal models such as our urothelium-specific integrin knockout.

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**Dr David Kent**  
*(Predictive Analytics and Comparative Effectiveness Center, Tufts Medical Center):*

New advances in clinical research methods and informatics and novel models of data sharing hold the promise of enabling a true ‘learning healthcare system’. Large administrative databases linked with electronic health records, new statistical methods for extracting causal information from raw data, and policy changes in US and European funding and regulatory agencies that have increased the public availability of randomised trial data may finally provide the substrate needed to deliver more personalised, targeted and efficient care. This care will be based on better understanding of how patients’ clinical
characteristics influence the risks and benefits of specific treatments in a way that other genomics have thus far largely failed to deliver.

**Dr Marita Kloseck (Western University):**

A number of recent innovations are impacting the ageing field. These include: telehealth and telecare, which provide remote monitoring between patients and healthcare providers; telemedicine video conferencing for more expensive, specialised services such as wound care, surgical follow-up, and oncology in remote area; ‘smart homes’, which provide customised lighting, audio/video requirements, surveillance and remote view camera systems; and personalised tracking devices for individuals with Alzheimer’s disease and dementia.

There is also an emerging focus on international robotic development. Japan currently has one of the greatest proportions of older people in the world and is turning to robots to meet the health, caregiving and social needs of its rapidly ageing population.

**Dr Mary Olmstead (Queen’s University):**

In animal models of addiction, optogenetics is allowing researchers to make rapid advances in understanding the role of different brain structures in behavioural responses. In humans, the possibility of using gene therapy to treat (but not cure) addiction seems likely in the next decade.

Still, we have to be careful not to become too invested in a particular technology or to expect that it will lead to a breakthrough in any field. No matter how innovative the technique, it is only as useful as the questions researchers use it to answer. Students sometimes have a difficult time understanding this; they want to work with a particular technique because it is considered state-of-the-art and cutting edge. It is vital to recognise that every methodology has its place and, without a strong theoretical rationale for using a specific approach, the resulting research is unlikely to have a major impact.

**Dr Jeffrey A Lieberman (American Psychiatric Association):**

Although healthcare moves forwards when there is some kind of scientific or technological breakthrough, an awful lot can change and improve simply following the implementation of practical knowledge; the development of sterile technique, for example, had enormous public health impact. We are about to see a similar type of development in psychiatry, as the strategy of early detection intervention begins to be more widely subscribed to and applied. When you look at certain illnesses, you find that there is often an appallingly long time period in which people are actively symptomatic before coming to diagnosis and treatment – an average of one year for cases of schizophrenia and psychosis, and over five years for depression. Models of care have therefore been developed which try and cut down the duration of untreated illness. I am certain that this early detection intervention strategy will have a transformative effect on the way healthcare is carried out.

Beyond this, I think the next innovation is likely to be the validation of diagnostic tests for mental illness. We are now beginning to see companies that are marketing genetic or blood-based tests for mental illnesses using proteomic or metabolomics assays. I predict that diagnostic tests based on imaging will become the standard, with either positron emission probe scanning or functional MRI being the measure of assessment.

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A final innovation of note is the increase of neuromodulation (brain stimulation). Historically, brain manipulation techniques (such as shock treatment and psychosurgical lobotomies) have gained notoriety, but now significant steps are being made in relation to transcranial magnetic stimulation, direct current transcranial stimulation and deep brain stimulation, which involve the implantation of electrodes into specific brain regions. This has been used in neurology to treat Parkinson’s disease and in psychiatry to treat depression, and could well be extended to other illnesses in the future.

**Dr Audrey Steenbeek (Dalhousie University):**

Social media may well play a large role in health promotion, education and disease prevention, especially when it comes to breaking the stigma surrounding sexual health and promoting healthy sexual experiences. We are also hopeful that technology can help with locating test results and maintaining confidentiality in ways that are more acceptable to youths.

Another area of potential innovation would be the development of a chlamydia vaccine and of better contraceptive methods.

**Professor Jeffrey Toretsky (Lombardi Comprehensive Cancer Center):**

Protein interactions occur through concentration-dependent phase transitions that can lead to collections of proteins based more generally on their biochemical properties, charge and/or hydrophobicity. In cells, these collections can even separate from the surrounding cytoplasm or nucleoplasm, which we call ‘phase separation’ and is well-studied in germ cells of lower organisms. The application of this idea to pharmaceutical development will change the nature of ‘druggable’ entities and the types of therapeutics that are developed.

**Dr Bernard Vallat (World Organisation for Animal Health):**

Since the World Organisation for Animal Health (OIE) has been mandated to improve animal health and welfare worldwide, the innovations which have marked its history mainly concern the major improvements in diagnostic tools and vaccine development, with marker vaccines and the progress made in polymerase chain reaction (PCR) having led to great advances being made in diagnostic methods. These have been a crucial means to better identifying and controlling animal diseases, thereby protecting human health in the process.

Additionally, OIE is currently involved in a revolutionary project that aims to create a global database of all pathogens of human and animal origin, including their genotype.

**Dr Geoffrey Payne (University of Northern British Columbia):**

The key technology that will continue to drive my field is the continued refinement and pushing the limits on imaging. This will enable us to continue to see smaller and smaller interactions of living microcirculation to truly understand the signalling mechanisms which are impacted by disease and repaired by treatment.