



# Engineering for health

**Engineering is at the heart of society, underpinning and continually improving the quality of our lives. The Royal Academy of Engineering brings together the country's most eminent engineers from all disciplines to promote excellence and support the engineering performance of the UK.**

**Biomedical engineering creates new medical technologies and systems that can greatly improve patient care and quality of life. The UK Focus for Biomedical Engineering is the Academy's forum for this increasingly important area of engineering in which the UK is taking a lead.**

## Summary

Modern medicine and healthcare rely heavily on engineering to deliver improved prevention, diagnosis and treatment of illness. These technologies are vital to the delivery of efficient health services through the National Health Service (NHS). However the contribution of engineering is often hidden within the health sector.

This paper looks at key areas of medical science and technology and at specific issues within the healthcare and medical world and uses examples to show the contribution of engineering in each area.

## Medical imaging

Imaging enables clinicians to discover information about normal and pathological conditions non-invasively. Initially, it was confined to giving information about anatomy – most obviously broken bones. Anatomical imaging using ultrasound, x-rays (including X-ray CT, the imaging of 'slices' to build up 3D pictures) and MRI continue to provide increasingly high resolution images of organs.

However, pathology is primarily associated with physiology and metabolism, and so functional imaging has been a major recent development of medical imaging. This includes nuclear medicine, contrast-enhanced MRI, Doppler and contrast enhanced ultrasound. At the same time, methods to analyse such images, to align them, and to combine images of different types, have also been developed by engineers to measure the progression of disease or the response to therapy.

## Surgery

Almost every aspect of surgery depends on engineering, from operating theatre design to the instruments used for surgery. Keyhole surgery and other minimally-invasive techniques depend on engineers to develop miniature cameras and lighting systems to insert into the body.

Endoscopes (probes to look inside the body), and other instruments enable surgeons to operate on patients via tiny incisions, allowing much quicker healing and better patient recovery than traditional surgery.

Medical robots are already used in eye, prostate, orthopaedic, cardiac and other areas of surgery, ensuring that fewer mistakes are made and that surgeons can carefully pre-plan surgical procedures, knowing that the robot will perform consistently.

## Simulation and training

Well-established in other sectors, such as the training of airline pilots and power station operators, simulation in the training of medical and surgical staff offers the potential for meeting many of the challenges posed by reduced resources, fewer hours and increased complexity of procedures.

Engineers work with surgeons and other practitioners to develop techniques and systems that match real-life facilities and procedures as closely as possible.

## Artificial joints

One million artificial hips, and a similar number of knees, are implanted in people worldwide each year. These are

designed, developed and manufactured by engineers and there is constant research to improve methods and materials and to extend the range of prostheses.

The rehabilitation equipment used to help patients following surgery is also designed by engineers, as are the many instruments that are used to assess quantitatively the results of surgery. The aim of all such surgery is to enable patients to regain as far as practicable their former independence and agility.

## Cardiac implants

The development of the silicon transistor made it possible for electrical engineers to produce the first pacemaker to be implanted in man in 1958.

A pacemaker is an example of a growing range of medical devices inserted in the chest using minimally-invasive surgery, to regulate and assist the beating of the heart. It uses low-power electrical pulses to speed up a slow heart rhythm or help control an abnormal or fast rhythm.

Pacemakers are externally programmable so that the optimal pacing mode can be selected for each patient. Sometimes, a pacemaker and defibrillator are combined in a single implantable device. Currently, there are 600,000 pacemakers implanted each year worldwide.

## Neural engineering

The interface between living tissue and non-living systems is already being addressed through systems that control diseases such as Parkinson's and epilepsy. Elsewhere, cochlear implants are

restoring hearing to many thousands worldwide each year. But these applications are just the first in a branch of biomedical engineering that promises to make the restoration and augmentation of human functions into a mainstream option for healthcare.

## Mobile health

mHealth is a developing discipline that has potential to make a huge impact on the delivery of healthcare services. The mobile phone can act as a platform for monitoring and delivering services to patients in their homes and promises to revolutionise the care of patients with long-term conditions.

The technology of mHealth will require engineers and medical practitioners to work together to develop systems that can help to liberate scarce resources while keeping the clinician in the loop as appropriate.

## Healthcare IT

Healthcare IT solutions, designed and implemented by software engineers, enhance patient care in the modern hospital and reduce operational costs. Examples range from Picture Archiving and Communications Systems (PACS) which allow X-rays and scans to be stored electronically and viewed on computer screens, to prescriptions that can be generated, transmitted and dispensed electronically. Other examples are less obvious: the great advances in fundamental understanding of health

and disease that have come from the human genome project were made possible by the engineering development of automated DNA sequencing machines. Integration of systems and project management are crucial to maximising the future take-up of technology and systems to promote health.

## Regenerative medicine

Engineers are working with biologists to develop and then commercialise systems that will enable health practitioners to deploy an ever wider range of regenerative techniques. Examples include stem cell implants and the development of tissue materials that will enhance the patient's own ability to self-heal.

Many engineering disciplines are needed to bring the technologies that will extend the applications of regenerative medicine and to prove its efficacy as a cost-effective treatment with long-term benefits.

## Independent living

The UK has an ageing population. In 2007, there were about 9.8 million people aged 65 or over in the UK, but by 2032 this number is projected to be as high as 16.1 million.

For elderly people living at home, new developments in monitoring technology can provide safety and security. Simple sensors can monitor health and be capable of summoning help in an

emergency, without requiring action from the user. Engineers have developed other home modifications such as self-closing taps and assistive devices that allow older people to remain in their own homes, with reasonable independence, for longer. This is important as it reduces pressure on social and medical services and ensures a better quality of life for older people.

## Conclusion

Engineering has a vital, underpinning role in improving health and healthcare services. The Royal Academy of Engineering is active in the field of biomedical engineering through the UK Focus for Biomedical Engineering. The group produces policy papers, organises briefing seminars and engages with the policy community to promote awareness of new technologies, their applications and implications for the delivery of healthcare.

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