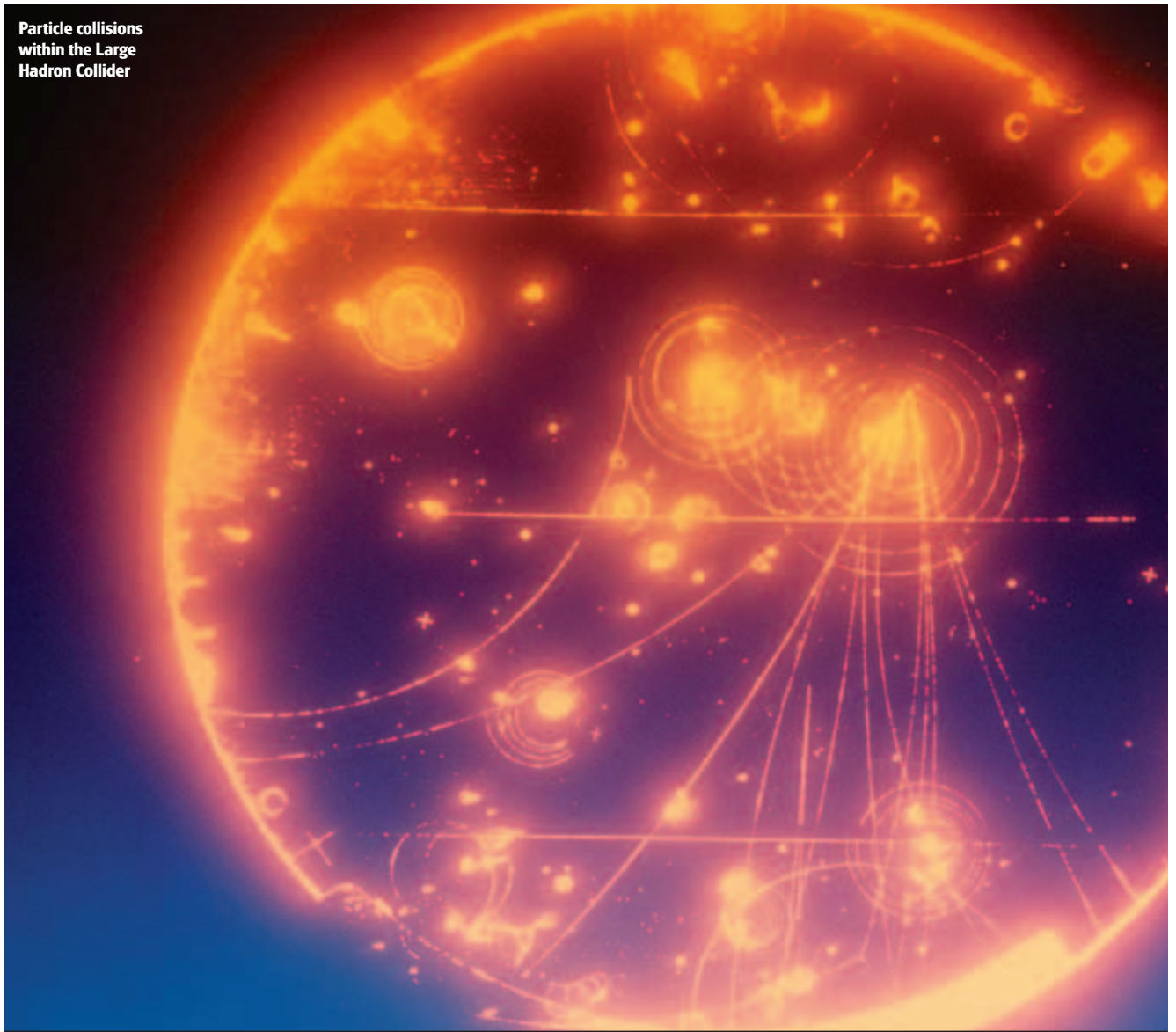


SCIENCE AND INNOVATION

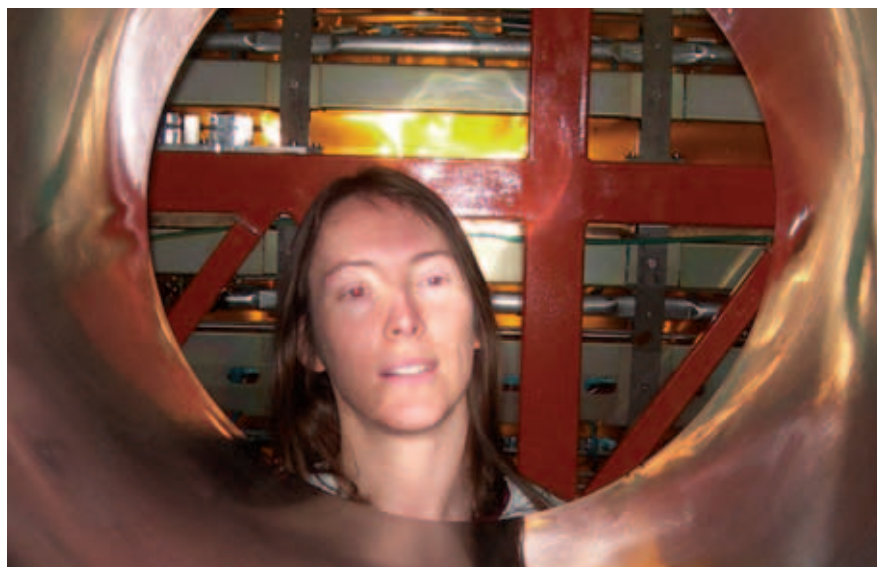
Particle collisions
within the Large
Hadron Collider



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Challenging the assumptions of physics

Physicist Dr Tara Shears talks to Martin Ince about what the Large Hadron Collider in Switzerland could tell us about the universe and ourselves

THINK OF AN atom, and you probably think of a bundle of protons and neutrons making up a nucleus, around which a mass of electrons orbit like planets around the Sun.

But Dr Tara Shears, reader in physics at the University of Liverpool, warns that things are really more mysterious, more complex and more interesting than that.

Dr Shears is one of the thousands of scientists around the world who are using the Large Hadron Collider (LHC) in Switzerland to delve deeper into the particles that make up the universe around us. This is big science at its biggest. Her experiment alone has 700 collaborators. But what will the LHC tell us about the universe and about ourselves?

Her first message is that those particles are less solid than they look. While electrons are 'fundamental' particles and do not seem divisible, protons and neutrons are themselves made up from smaller particles called quarks, held together by other particles called gluons. The LHC is the best machine yet for looking at their properties.

The reason for spending billions on the LHC is, according to Dr Shears, that "there is no other way of looking at the universe at its most basic level." She explains: "We use machines like these to create very high energies. At a temperature about 100,000 times that of the centre of the Sun, there are no protons and neutrons. These are the conditions of the first billionth of a second of the universe, when only fundamental particles existed.

"We create them by using magnets to accelerate protons to a speed about 20km a second less than the velocity of light, and then colliding them in a space about as thick as a human hair. Then we image that collision, which means huge amounts of data as we do it 40 times a second. Anything we see has got to be a fundamental particle." This minute accuracy has to be sustained in a machine 27km in circumference, with 9,300 precisely-controlled magnets.

The LHC experiments are intended to verify and advance something that Dr Shears says is "known rather hubristically as the

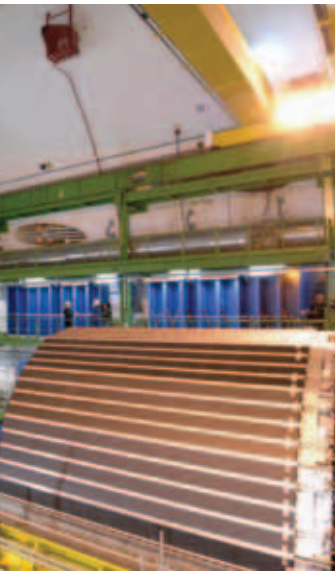
Standard Model". Thought up in the 1970s, the Standard Model regards the universe as being made up of a dozen particles and four forces. While no observation has ever contradicted this model, there are loose ends, such as its failure to account for gravity, one of the four forces. Dr Shears says that we now understand gravity as an interaction in which particles interact by exchanging another particle. You can think of their mass as depending on the strength of that interaction.

The particle, postulated by Peter Higgs of the University of Edinburgh and others in the 1960s, is the Higgs Particle. Dr Shears says that if it exists, the LHC is the machine to find it. Looked at close up, she says, matter is mainly empty space. The existence of forces by which pieces of matter affect each other shows that the universe is not really empty and instead contains a mass of particles hurtling into and out of existence.

"If we can find the Higgs," she says, "we'll know that our understanding of the universe is correct. If not, we'll know that we need a new viewpoint."

In addition, the LHC allows other puzzles about the standard model to be investigated. We now know that the material that we are aware of and can drop on our foot only accounts for about four per cent of the universe. Twenty-three per cent of the rest is dark matter, which has mass but does not interact in other ways with the visible universe, and the other 73 per cent is dark energy. Experiments on the LHC can test our ideas about dark matter and dark energy, which Dr Shears describes as "a layer below the Standard Model".

A further problem that ought to be addressed by work at the LHC is to do with antimatter – matter made up of particles with opposite properties to those we usually see. The most obvious is the positron, which is identical to an electron but with a positive



Far left: Tara Shears examines a component of her experiment at the Large Hadron Collider (LHC) in Switzerland

Left: The LHC has a circumference of 27km and contains equipment weighing 38,000 tonnes

electrical charge. When antimatter meets normal matter, both are annihilated and energy is produced. As Dr Shears points out, this is no mere theory. Positron Emission Tomography (PET) scanners in hospitals work by observing this energy.

The issue is that according to the Standard Model exactly the same amount of matter and antimatter should have been created when the universe formed, and the whole lot would be destroyed in under a minute. As we are here, we can tell that a small excess of normal matter was created.

Perhaps to the relief of funding agencies around the world, Dr Shears adds that the LHC will not necessarily be followed by another, even bigger, particle racetrack. It may be possible to use a linear, rather than a circular, accelerator to collide electrons and positrons, using lower energies but more precision.

As she says: "They are already fundamental particles, there is no obscuring stuff when they collide." Alternatively, there could be a paradigm shift in the technology, maybe with new forms of magnets to accelerate the particles or completely new lines of investigation, perhaps using energetic cosmic rays from elsewhere in the universe.

Whatever the future holds, Dr Shears thinks that the intellectual value of CERN is not just reserved for a favoured few or experts such as herself.

In Dr Shears' opinion, astronomy and particle physics are fascinating to everybody, and they are known to regularly attract young people into pursuing a career in science. Spectacular results from the LHC would persuade yet more talented people into this key area of scientific, technological and economic life. ■

www.lhc.ac.uk

Can veterinary diagnostic devices help control livestock disease?

Attitudes to point-of-care disease identification devices are key to their success

POINT-OF-CARE veterinary devices for pathogen and disease identification provide opportunities to reduce the social, animal welfare and economic impact of livestock diseases. These devices allow tests to be run at veterinary surgeries or on farms rather than sending samples to a laboratory. Having test results rapidly available allows quicker diagnosis and decisions on appropriate action to be taken.

Ann Bruce, a researcher at the ESRC Innogen Centre at the University of Edinburgh, undertook a three month ESRC Placement Fellowship with the Department for Environment, Food and Rural Affairs to study

the attitudes of vets, farmers and other food chain professionals to adopting these technologies. The research forms part of a suite of ESRC-funded projects at Innogen studying farmers' attitudes to new technologies.

Her work showed an awareness that these devices have potential advantages but the main barrier to their adoption was a lack of confidence in the reliability of the results they might produce. As the consequences of decisions made with the aid of the devices increased, the need for confidence became more acute.

There were also concerns that communication of the disease situation might get out of control, and about a

potential loss of information for disease surveillance and epidemiological study. And because point-of-care devices codify the complex knowledge of laboratory testing into an easily understandable format there may be a temptation to rely on them too much, devaluing clinical judgement and consequently misdiagnosing disease.

Farmers interviewed for the research

were interested in using these devices, subject to their cost and usability. But they added that they would continue to rely on veterinary expertise to advise on which devices to use and how, and for interpreting and acting on the output.

However, the sample of farmers was small and since these devices are not yet widely available, attitudes could change with increasing experience.

These devices are being introduced at a time when there is increasing stress on the governance of disease control and on the sharing of the responsibilities and costs. These are likely to result in shifting relationships between government, vets and farmers. Many respondents identified these relationships as the key to effective disease controls. So the landscape within which these devices might be adopted could be very different in future years. ■

There may be a temptation to rely on point-of-care devices too heavily

www.genomicsnetwork.ac.uk/innogen



On-farm testing gets rapid results and leads to quicker diagnosis

Blurring the boundaries of life

How research into stem cells is redefining life science ethics and regulation

STEM CELLS ARE celebrated and emblematic. People have heard of stem cells. Though they are not much used today for therapeutic purposes, they stand for the hope of a new, smart kind of medicine that is connected to new understandings in biology in the age of the decoded genome, and which is also 'personal'. Banking stem cells from your umbilical cord or using advanced techniques to create stem cells identical to your own may allow medics to grow cells that are specific to your needs.

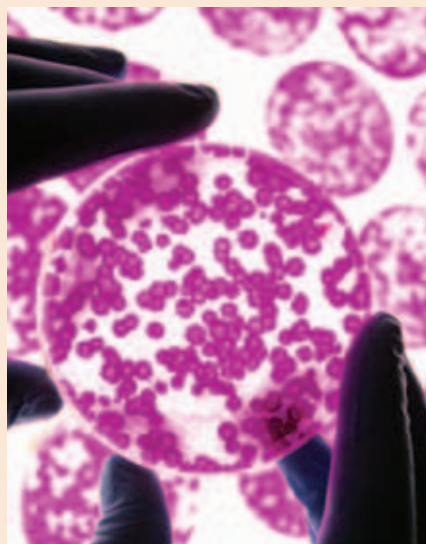
Stem cell therapies may inaugurate a new age of medicine in which previously impossible things – the growth of replacement organs, repairs to spinal damage and much more – could become feasible or even routine. These developments have acquired the label of 'regenerative medicine', though regeneration may also make use of other techniques besides stem cell technology.

A key source for stem cells is the embryo. Early in the embryo's development, some cells are set to develop into the placenta. Others – concentrated in the middle of the bundle of cells – will develop into the baby's organs, skin and blood. The key thing is that these cells are not yet of any specific type. They are capable of becoming any type of cell in the body. These embryonic cells are what the body 'stems' from. The process by which the cells do this, and how they develop into specific, non-interchangeable cell types, is of fundamental scientific importance. So stem cells are as important to basic research as they are to medical practice.

Because of these therapeutic hopes and the biological importance of stem cells, there has been a lot of emphasis on winning support and funding for research in this area. But, as virtually everyone in the field acknowledges, these are troubling issues for at least two reasons.

First, research work on these embryonic stem cells normally implies that cells must have been obtained from a human embryo at some point. This has led to strong opposition to stem cell work in the US and by many in the Catholic Church. Second, once one has created a line of stem cells – whether from embryos or using some other technique – there is a question about what status these extraordinary cells have. Are they just ordinary pieces of biological matter or do they merit a special dignity?

When a new regulatory challenge arises it is common to call for an ethical review, and a lot of effort has gone into working out



Is humanity right to create life in the lab?

what moral standing embryonic cells may have. But ethical reviews have tended not to resolve the feelings of unease. Social scientists have understood more quickly than others that one key thing about stem cell work is that it leads to the blurring of boundaries and the development of new kinds of entities. Anthropologists have long observed that many cultures tend to react strongly to such challenges to their classificatory systems. Feelings of unease or even revulsion are commonly stirred.

Stem cell research has brought new kinds of things into existence. Human stem cells can be propagated and grown on, almost indefinitely.

These new stem cells are genetically equivalent to their precursors but would never have arisen through natural processes. They are human creations. In recent years, it has been shown that adult cells can be induced (or tricked) into behaving rather like embryonic stem cells, and there are now pseudo-stem cells.

So-called 'admixed embryos' are even stranger. They were devised as a means to carry out stem cell research relating to

people but using many fewer human embryos. Cells from cows or rabbits were stripped of their nuclei and human material introduced in their place. These were not hybrids of humans and rabbits or anything of that sort, as there was no merging of DNA. In any case, the cells were not allowed to develop beyond a few days. But they did prove to be useful research models for understanding how human stem cells functioned and grew.

There are plenty of philosophical, religious and bioethical frameworks available for thinking about these matters, but they all tend to depend on a prior decision about how the entity is to be classified. Admixed embryos are genuinely novel. They consistently confound our classificatory systems. This causes problems for attempts to fit them into our pre-existing ethical frameworks since the frameworks can only help once we have decided what admixed embryos really are. All the hard work and controversy surround their real identity. Also, part of our unease with these admixtures arises from the very fact that they are so hard to categorise; we do not know where we are with them. They are, quite literally, the unknown.

With their boundary-challenging character, stem cells may sound like the perfect complement to social scientific theorising. But they also fit well with another favoured sociological theme – globalisation. Stem cell research is a demanding and expensive undertaking, but not one beyond clinics and laboratories around the world. For example, a lot of interest is being shown today in India, China and Taiwan. But different cultures' views of the status of embryonic cells or the rights and duties of patients may differ.

There are technical demands on international stem cell collaboration. Researchers don't want lines that have not been maintained in the strictest circumstances and may fear that 'results' reported from other countries are artefacts generated by the way the line has been maintained. But there is globalisation not only of the product but also of the ethical framework. Bioethics is now often treated as a purely technical discipline: as a universal set of techniques to be applied across the globe irrespective of their local salience.

Stem cells are deeply fascinating for social scientists. They reveal how life-science innovations may upset our customary boundaries and classifications, provoking disquiet. They also highlight the way in which global markets are increasingly held together not only by global technical standards, but by supposedly global ethical standards too. ■

www.genomicsnetwork.ac.uk/forum



PROFESSOR STEVE YEARLEY
Director, ESRC
Genomics Forum



Synthetic Aesthetics resident Oron Catts at the Iwasaki Lab at Waseda University, Tokyo

The Synthetic Aesthetics project explores new collaborations between synthetic biology and the creative professions

artists and designers are spending two weeks in synthetic biology laboratories, and six scientists and engineers are spending two weeks in art and design studios and workspaces. Although it is relatively common for artists and designers to visit science laboratories, it is unusual for these visits to be reciprocal, with scientists and engineers spending an equal amount of time in the art studio.

The Synthetic Aesthetics residents come from all over the world. The scientists and engineers represent a broad range of different approaches in synthetic biology, and the artists and designers work in many different areas including architecture, bioart, industrial design, music and even smell.

Questions that the ESRC Innogen Centre researchers are interested in answering include: What does it mean to design nature? What insights can design offer in engineering microscopic entities for a human-scale world? Can collaborations between synthetic biology and design inform and shape the developing field? And what can art and design learn from synthetic biology? The project will produce novel social scientific research that analyses and reflects on these interactions.

The researchers' aim is that these exchanges will develop into long-lasting mutually transformative relationships. They aim to catalyse interactions, develop transferable knowledge and skills, and establish a continuing network of collaborations. The hope is that the exchanges will be more than one-off experiences, and that the interactions will contribute to ongoing work in both communities, developing new spaces for cooperation and debate. Long-term interaction could enable design concerns to be reflected better in synthetic biology, allowing technology development to be more inclusive and responsive.

Art and design can encourage thought and debate in unique and innovative ways. The researchers hope that the project will produce a critical interrogation of synthetic biology that goes beyond representation and beautification. The project aims to construct the groundwork that could lead to new forms of science and engineering, new schools of art and design, and new approaches to societal engagement with synthetic biology. ■

www.syntheticaesthetics.org

Bringing together synthetic biology, art and design

New research hopes to shed light on the collaboration between synthetic biology and creative professions

SYNTHETIC BIOLOGY IS a new approach to the life sciences that aims to construct novel living systems, and redesign existing ones for useful purposes. Social scientists are becoming involved in the development of this emerging field from the outset. It is a topic of active research interest across the whole of the ESRC Genomics Network, and will be the subject of an ESRC Seminar Series in 2011-12.

Researchers at the ESRC Innogen Centre have recently had the opportunity to take their research on synthetic biology in new directions with the award of a grant on 'Synthetic Aesthetics' from Britain's Engineering and Physical Sciences Research

Council and the National Science Foundation in the US.

The Synthetic Aesthetics project is a collaboration between the University of Edinburgh and Stanford University in the US. The project team is truly interdisciplinary, involving two social scientists, two bioengineers and a designer. The ultimate aim of the project is to bring together synthetic biologists, designers, artists and social scientists, to explore new collaborations between synthetic biology and the creative professions.

The main focus of the project is 12 embedded residencies between July and December 2010. During these residencies, six

The technology of identity

Can DNA tell us who we are, not just establish our genetic identity?

THE IDEA THAT genetic and genomic technologies can provide uniquely discriminating markers of personal identity is widely accepted today. An important factor in stimulating this belief has been the growth of DNA profiling as a technology of identification, be it for resolving cases of disputed paternity, for identifying disaster victims or, through the use of forensic DNA databases, to identify suspects in criminal investigations.

But the idea that DNA analysis offers a direct line to the essence of identity can also be exploited in other ways, for instance by commercial companies offering direct-to-consumer tests for genetic ancestry, predisposition towards various diseases, and other personal attributes. Compared to more simple DNA profiling, such personal tests pose considerable problems of reliability and interpretation.

The relationship between genetic inheritance and phenotypic attributes is a matter of probability rather than straightforward causality. Ancestry tests, in particular, provide information only about a very small and possibly unrepresentative proportion of one's forebears. Nonetheless, consumers of such tests often invest them

Personal DNA tests pose considerable problems of reliability and interpretation

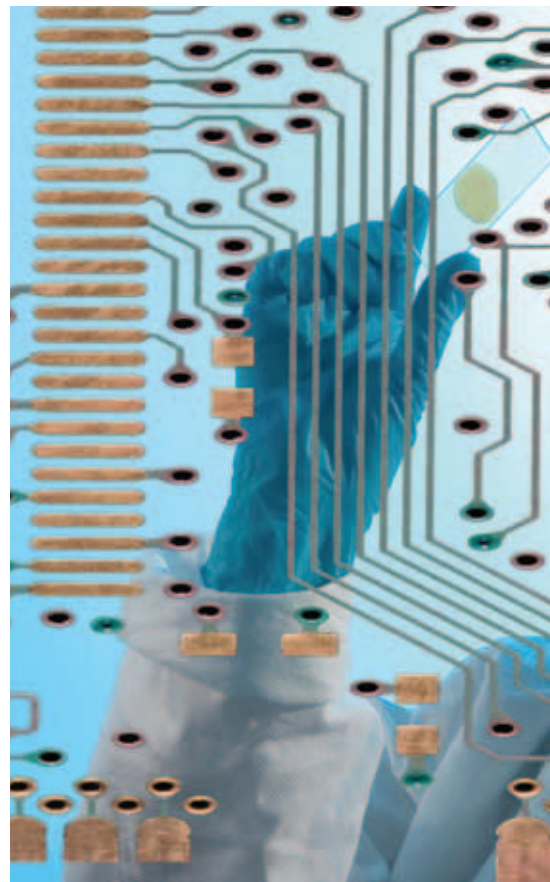
with considerable credibility, even going so far as to revise their claims about their own race or ethnicity in light of genetic findings.

Excessive faith in DNA as a source of information about identity is not confined to the purchasers of direct-to-consumer genetic tests. Research by the ESRC Genomics Network looks at the UK Border Agency's pilot project to assess the possibility of using genetic ancestry tests to help distinguish genuine Somali asylum seekers from Kenyan imposters. The project went ahead despite objections from population geneticists that such tests were hardly definitive in revealing geographical origins, and said nothing about the purely social issue of nationality.

Similarly ill-founded assumptions about the genetic basis of ethnic and racial identity commonly find their way into pharmaceutical trials and prescribing practices.

In 2005 the drug BiDil was licensed for use among African Americans on the basis of a clinical trial that used racial self-categorisation as a surrogate marker for presumed genetic differences.

Critics argue that properly-conducted pharmacogenetic trials will eliminate such assumptions by articulating genuine



scientific classifications of patient groups based on genetic ancestry and other characteristics. But some social scientists have pointed out that social assumptions about racial identity continue to inform the way that such classifications are constructed.

DNA profiling, ancestry testing and pharmacogenomics all involve the management and manipulation of bio-information. The ease with which such information can be reproduced and communicated between users is a key

Explanations for schizophrenia among black African-Caribbean people

FOR SEVERAL DECADES, data from psychiatric epidemiology and other research have shown that significantly more black African-Caribbean people with diagnoses of schizophrenia are admitted to adult in-patient and low-to-medium secure psychiatric facilities than all other ethnic groups.

There is controversy about why these ethnic disparities occur, especially among two broad groups of professionals: clinical researchers in psychiatric epidemiology and black mental health activists from research, policy, charities and voluntary organisations.

Research by the ESRC Centre for Social and Economic Research on Innovation in

Genomics has addressed this topic by engaging with the following key question: how and why do epidemiologists and activists award different kinds of authority and credibility to their explanations for these ethnic disparities? The research has been carried out through participant observation at conferences and debates, and through interviews, some at the Institute of Psychiatry, part of King's College London.

This research has shown that a number of explanations continue to be proposed for these disparities by both groups. Epidemiologists consider these disparities to be, primarily, a reflection of 'real' mental illness, associated with higher levels

of social disadvantage and adversity among black people than other ethnic groups. Activists consider the disparities to reflect more coercive admissions, misdiagnosis, and institutional racism found inside and outside psychiatry.

There is little consensus between these two groups about how ethnic disparities should be described and explained through research; whether schizophrenia is a valid category of diagnosis and how race/ethnicity should be used in research; or about what kinds of evidence about ethnic disparities is permissible and how this evidence should be interpreted.

These differences about ethnic disparities draw on diverse interpretations of the nature and purpose of science in psychiatry, the relevance of history to understanding contemporary epidemiology, and the intricate relationship between science and politics.



Alamy

Is our faith in the reliability of DNA testing unfounded?

factor in sustaining the view of genomics as a unique key to identity. But it also gives rise to unprecedented social, ethical and regulatory challenges. Effective data protection regimes will go some way towards addressing these challenges. But we also need a proper understanding of just what genomics can and cannot tell us about who we really are. ■

www.genomicsnetwork.ac.uk

These conflicting interpretations point to considerable distrust and disagreement between clinical researchers and activists about the scope and emphasis of appropriate mental health policy and service provision for black people.

These different positions have shaped consultations on the Department of Health's Delivering Race Equality programme (2005-2010), the Mental Health Act 2007 (Revised Code of Practice), and the recent New Horizons proposal to replace the National Service Framework for Mental Health (1999). There is a great deal at stake for epidemiologists and activists in how the problem of disparities is defined and how it may be addressed through common endeavour with, and on behalf of, black communities. ■

www.genomicsnetwork.ac.uk/innogen

The future of police forensics

New studies of genetic technologies for police work hope to fine-tune evidence-based investigation

BOTH POLICE PRACTICE and the criminal justice system have relied increasingly on forensic DNA technologies to identify and prosecute offenders. Some aspects of this process are better known than others: while the development of the National DNA Database has been the subject of extensive academic, political and public debate, the ways in which forensic DNA technologies are implemented and used in everyday policing have received comparatively little attention.

A new project at the ESRC Centre for Genomics in Society (Egenis) aims to redress the balance a little. Its research into the use of forensic DNA technologies in police practices is led by research fellow Dr Dana Wilson-Kovacs and Dr Christine Hauskeller. "The current drive for evidence-based policing is intended to turn criminological knowledge into more cost-effective police practice and increased public confidence. It is important to understand how this process takes place, what are its tensions and how they can be resolved successfully," says Dr Wilson-Kovacs.

The Science and Innovation in the Police Service Strategy for 2010-2013 – published in March 2010 – commits the service to building strong partnerships with the scientific community and to focus research in areas that will have the greatest impact on public safety. "Forensics and genetics are instances where modern science can be applied to frontline policing, with the potential of bringing offenders to justice quickly and creating substantial long-term savings," explains Dr Wilson-Kovacs. "The Forensics21 Programme developed

by the National Policing Improvement Agency has facilitated the development of technology that can generate a DNA profile from a sample in a matter of hours, outside the laboratory. It is this aspect that Egenis' project will examine. The project will document policing decisions on the use of genetic knowledge in order to provide crucial information on the benefits and limitations of genetic technologies for police work.

"Our analysis will focus on the social, organisational and scientific issues raised by bringing these technologies into everyday police practice, examining the

factors considered in their development and adoption, and the ways in which they are prioritised by various actors and agencies. We will look at the changes which are envisaged in day-to-day police routine and the collection and processing of data and its analysis and interpretation.

"We will document how change is perceived and prepared for at an institutional level, the place and role of the forensic services as a large institutional user of genetics and the introduction of these technologies to frontline policing," said Dr Wilson-Kovacs.

The findings will help fine-tune evidence-based policing. They should permit a more detailed understanding of the challenges of implementing genetic technologies, and of the transfer of innovation across force borders and different sections of the police service. ■

www.genomicsnetwork.ac.uk/egenis



Alamy

Moulding the future of plastic electronics



Could our packaging soon display interactive information?

THE COALITION GOVERNMENT has taken a bold decision to back British innovation by supporting the emerging plastic electronics industry. A report from the Advanced Institute of Management (AIM) Research sheds light on this exciting new sector.

"Hollywood has depicted products that use flexible electronics – from animated, electronic newspapers like Harry Potter's *Daily Prophet* to smart pill packaging that beeps your doctor when you forget to take your medication. But now, plastic electronics has evolved from science fiction to science fact," according to Dr Zella King from Henley Business School, AIM innovation Fellow and author of the AIM Research report. "Thanks to developments, we could be seeing printed electronics appearing in our everyday lives, from large-area, ultra-efficient lighting

and low-cost solar cells in new buildings, through to intelligent labels that authenticate high-value branded goods."

The government has identified plastic electronics as a key area for development. The launch of the UK Plastic Electronics Strategy in 2009 was coupled with an £8 million investment administered through the Technology Strategy Board. The aim is to promote the growth and development of the industry through collaborative projects. The plastic electronics industry is predicted to be worth \$300 billion by 2030 and Britain is leading the way on global innovations.

Market demand for plastic electronics goods is vast, and some companies have been quick to embrace its potential. Hewlett-Packard is advocating the move towards 'Information Surfaces' – plastic sheets that can display paper-like, high-detail text

Courtesy of Professor Alison Walker, University of Bath

Neuroscience, identity and society

Is every thought and action we take determined by the way our brains work?

ARE WE OUR brains? New ESRC-funded research in neuroscience by Martyn Pickersgill, University of Edinburgh, is revealing the detailed workings which underlie the brain's role in determining what we think, how we speak and how we fit into society.

Through their work, including powerful imaging studies, neuroscientists are providing new ways of understanding ourselves, our social relations and our societies. In so doing, they are contributing to long-standing debates concerning free will, morality, and madness. In the process, neuroscience challenges existing practices and stimulates new collaborations and interactions. New engagements with lawyers and teachers are particularly important examples of this.

With the rise of neuroscience has come a shift in how we see ourselves. Rather than being people in control of our own destinies – or, conversely, slaves to our genes – many individuals in Britain think of themselves in terms of their brain processes. They go for a run because that releases endorphins and makes them happy; they know that when they feel sad it's just because they don't have enough serotonin. We are starting to think that

thought, feeling and behaviour are mediated through the workings of the brain.

Of course, it's not quite as simple as that. These new ideas about neuroscience, identity and society don't simply replace longstanding understandings of mind and body. Instead, they sit alongside them. People draw not just on popular neuroscience, but also on the language of genetics, psychology and sociology, to describe themselves and their thoughts and feelings. So yes, we are our brains – but we're not just that, and not all the time.

Alongside developments in brain research come new social and ethical concerns. As with genetics in the 20th century, the neurosciences are creating knowledge about the world that we don't yet have the social and policy tools to handle.

Neurosciences are creating knowledge about the world that we don't necessarily have the social and policy tools to handle yet

Contrary to some fears, it's clear that neuroscience is not some kind of 21st-century phrenology – the 19th-century idea that the skull's shape can tell you something about a person's character. Few neuroscientists can be said to be so deterministic. But that doesn't mean we should avoid asking hard questions of scientists or discussing the social and ethical concerns that arise from their findings.



Some neuroscientists are studying deception. But does this really tell us anything useful about lying? Many would argue that lying is an inherently social activity, and therefore is not something laboratory science can fully account for. Even assuming it could, is the science really strong enough to be used in the courts, as some people hope it is? Many scientists doubt this. And what about the studies themselves? What kinds of other clinically-relevant information might neuroscientists find out about someone by imaging their brain? This is a very real concern.

Research scans may reveal the presence of abnormalities such as brain tumours. What training do scientists need in order to identify them; how might this affect the way studies are funded; how does it change scientists' relationships with their work; can informed

Science Photo Library

as well as interactive media. However, some say that companies have yet to fully understand the breadth of the revolution taking place and the potential impact on their businesses. "British industry needs to realise that this is no longer the sole domain of electronics companies," says Dr King, "it is open to anyone seeking to add value to their existing product range."

"Plastic electronics can unlock a plethora of possibilities and benefits," adds Plastic Electronics industry expert Cathy Curling of Curling Consulting. "With a collaborative, multi-disciplinary approach involving British designers, technologists and market-led end-user companies and organisations incorporating PE devices into their products, Britain will be well-placed to create significant commercial value for the nation's economy." ■

www.aimresearch.org



Scientists are studying whether our brain determines our character

consent procedures deal with this; what responsibilities do scientists have towards their research participants?

None of these are easy questions; nor can they be left to science alone to answer. They demonstrate how, no matter how hi-tech neuroscience becomes, it is a resolutely social activity. It is about people, for people, undertaken in a society. Neuroscience will need to build further collaborations with ethicists, social scientists and other professionals, and continue its dialogue with the wider public, to grapple with its complex social and ethical dimensions. We all have a stake in the brain. ■

www.neuro-societies.ed.ac.uk



Avian flu may not have affected Britain, but it remains a threat elsewhere in the world

Pandemic response report

While Britain has remained relatively unscathed by breakouts, our response to the threat needs refining

THE PAST YEAR has seen the swine flu H1N1 pandemic sweep the world. And avian influenza remains endemic in a number of countries, particularly in Asia. Fortunately neither has resulted in the 'big one' – a pandemic on a scale and intensity which results in massive human mortality. But this is no argument for complacency. Pandemic threats – from influenza or from other sources – remain as present as ever. Building our resilience to emerging infectious disease impacts, particularly in places where they are most likely to arise, must remain on top of global health security priorities.

A new book in the ESRC-funded Social Technological and Environmental Pathways to Sustainability (STEPS) Centre *Pathways to Sustainability* book series – *Avian Influenza: Science, Policy and Politics* – lays out the lessons from the international avian influenza response. The book is based on an analysis of the politics of the policy process, both at the international level, and in four countries in south-east Asia: Cambodia, Indonesia, Thailand and Vietnam. It suggests a way forward based on the principles of the One World, One Health movement which aims to bridge the gap between human and animal health concerns.

A key challenge for the future is to encourage collaboration between the wildlife, livestock and human health sectors. For it is at the interface between animals (both wild and domestic) and humans that new disease risks lie. All too often disciplinary, professional and organisational silos mean that the emergence

of disease is not spotted early enough. The result is that diseases spread, often very rapidly given the way connections exist in a globalised world. Fostering such collaboration is at the heart of the new One World, One Health approach.

One of the key lessons learnt from the international response to avian influenza is that the existing organisational architecture is inadequate. Developed after 1945, the international institutions have mandates appropriate to a very different world

with very different challenges. No-one seems to be in charge of the 'pump handle' – the critical control point that affects disease emergence and spread. New funding and governance arrangements are urgently required.

Too often we see separate laboratories being established for human and animal diseases, parallel training programmes being run for medics and vets and overlapping responses unfolding on the ground sponsored by different agencies. While coordination mechanisms exist, and have certainly improved, they often have little clout in the face of sectorally-focused interests, budgets and mandates.

A major rethink of the incentives and institutions is required, moving from rhetoric to action. We have been lucky (so far) with avian and swine flu, but our luck will not continue indefinitely. ■

www.steps-centre.org/ourresearch/epidemics.html

Building our resilience to emerging infectious disease must remain on top of global health security priorities



Adapting to age

Martin Ince finds out more about the link between how active we are and the rate at which our brains age

AS POPULATIONS AROUND the world get older, scientists as well as policy-makers are paying more attention to ageing. But Professor Doug Turnbull, director of the Centre for Brain Ageing and Vitality at Newcastle University, part of the UK Research Councils' Lifelong Health and Well-being programme, sees one big problem: "We have very limited understanding of the mechanisms of ageing."

As he explains it, ageing research is a new and vital area in which the fundamentals are still missing. "We know that the biggest risk factor for Alzheimer's Disease and Parkinson's Disease is age. But the same is also true of breast cancer. What changes allow these diseases to develop?"

Professor Turnbull's Centre is part of Newcastle's Institute for Ageing and Health (IAH), run by Professor Tom Kirkwood. The IAH is funded by a wide range of bodies and looks at the social and policy aspects of ageing as well as its biological and medical roots. Professor Turnbull says that the Centre demonstrates interdisciplinary research in action. It gains from being part of an Institute where there is a lot of complementary expertise and infrastructure.

He explains that the two parts of the Centre's title – brain ageing and vitality – are closely linked. At 57, he has realised that he can no longer play squash with the aggression he brings to his sporting life. Rather than playing more slowly, he has taken up golf,

which he still plays at full tilt.

He says that we know too little about the connection between ageing and vitality. "Our approach to exercise and nutrition could change if we had a better appreciation of how they affect ageing. What exercise do you need to do at 57, or 67, or older? We know that older people have thinner, weaker muscles. As well as making allowances for this, we need to know what we can do about it and why it happens. Here we have a direct link between basic science and improved old age. Older people have falls because their muscle power is reduced. It is certainly possible to do something about this."

As a new science, ageing research needs to expand. The Centre has brought in money to support 13 PhD students as well as more senior researchers. In addition, ageing has been built into Newcastle's undergraduate courses in medicine and biology.

The Centre's work looks at ageing from many angles including neurology and neurodegeneration, nutrition, exercise, biochemistry, and reproductive ageing.

The last of these is partly about gender differences, and shows that ageing research is not just about the very old. While men produce sperm for many decades, women start out with a supply of eggs and release them one at a time. Beyond a certain age, the eggs

have steadily more defective chromosomes, meaning lower reproductive success and more risk of birth defects. Professor Turnbull asks, "What is the mechanism that causes this, and what can we do about it?"

His own research is about mitochondria, key components of all human (and animal) cells. While they become defective as people age, some younger people also suffer from mitochondrial problems which have a genetic connection, almost as if they are ageing prematurely. For him this opens up a more interesting question, which is why we age at all.

Because ageing encompasses a vast span of disciplines, one issue for the Newcastle researchers is to prioritise key research areas. Professor Turnbull says that the answer is "to go for high-quality research where you have or can bring in good people. We insist on being internationally competitive and on being interdisciplinary. If we look at some particular molecule, we might want to know what it is, how it works in human muscle, and how we put that function right when it goes wrong."

But he says that his own field, brain ageing and neurodegeneration, is inevitably a priority. "It is a key area for many individuals, and for society as a whole," he says. "This means that we must understand the mechanisms of ageing that lead to neurodegeneration. If you look at the brain damage caused by neurodegenerative disease, you see it is very widespread. So even when we know more, prevention is likely to be the emphasis, not just regeneration."

The massive increase in the numbers of the 'oldest old', people 85 or beyond, is almost as striking for Professor Turnbull as the way in which older people now sustain their abilities. These two factors have changed our perception of age and also of work. We have a better appreciation of the varying rates at which people age, which suggests that fixed retirement ages are a poor idea. There are also wide variations in work itself: "You would struggle to work beyond the age of 65 or so as a manual labourer."

Ageing he says, can be physical or mental, and is very individual. There are now plenty of creative people in their 70s, but they need to know how to use their creativity when mind and body are less energetic than before. "People adapt to being older in a variety of ways. Society now has to help them do this. For example, I now see fewer patients and spend more time supporting younger doctors, although I love being a doctor." ■

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Anti-GM campaigners still believe that the controversial crops will end in disaster

GM crops ten years on: Hope, hype and reality

The divisive debate about GM rages on, but how has this controversial technology served us in the last ten years?

A DECADE AGO there was much hope and hype about the potential of Genetically Modified (GM) crops. They were going to feed the world and solve poverty and development issues. It was claimed that pest-resistant crops using so-called Bt technologies to resist insect predation could reduce pesticide use and improve farmers' incomes, and that technologies for dealing with drought or nutrient deficits were in the pipeline. GM crops would help poorer farmers in the developing world, with a 'gene revolution' succeeding the 'green revolution' of previous decades.

However, others predicted disaster: GM crops would result in environmental and health catastrophes and global domination of agriculture by large corporations. Just as the pro-GM lobby could be accused of excessive, unfounded hype, anti-GM campaigners often generated doomsday scenarios based on limited evidence.

In reality a more complex and mixed story has emerged. In some circumstances, some farmers have benefited from GM crop technologies while others had bad experiences or were bypassed altogether. But even now, wild claims are still made and false

expectations generated.

GM crops have expanded rapidly in some locations. Annual assessments by Clive James of ISAAA, the International Service for the Acquisition of Agri-biotech Applications, show GM crops sweeping the globe selectively. GM crops were planted in 25 countries in 2008, but only eight countries planted more than a million hectares.

About 98 million hectares out of a global GM crop area of 125 million hectares were grown in just three countries, by large-scale farmers: the US (62.5 million), Argentina (21 million) and Brazil (15 million). The GM crops that have been commercialised are primarily insect-resistant Bt maize and cotton, and herbicide-tolerant soy.

A recent book by Robert Paarlberg, *Starved for Science: How Biotechnology is being kept out of Africa*, again makes the case for GM crops as a solution to agricultural development.

Paarlberg argues that Africa's poor have scandalously been denied the vital, life-saving technology of GM crops because of European anti-GM campaigns. He claims that inappropriate, precautionary biosafety regulation is a major hurdle to the widespread

adoption of poverty-reducing technologies.

Paarlberg's arguments have been picked up by policymakers and lobby groups, the latter arguing the tide is turning in favour of GM crops as a result of the political recognition of the global food crisis. New efforts are making the case for a GM solution, especially for the potentially vast markets of the developing world, for example through the industry-based Alliance for Abundant Food and Energy.

A COMPLEX STORY WITH MIXED IMPACTS

Dominic Glover's research at the ESRC Social Technological and Environmental Pathways to Sustainability (STEPS) Centre reveals a complex story with mixed impacts. Glover shows that economic returns are highly variable. GM crops only perform well in good varieties, GM seed start-up costs and technology fees are sometimes too expensive for poorer farmers, and major adopters are usually richer, with more land. Meanwhile the institutional and policy environment is vital: without support, credit and sustained backing, new technologies often fail.

LESSONS FOR THE FUTURE

The 'pro-' versus 'anti-' fundamentalists of the GM debate have become entrenched. How do we get beyond this stalemate? STEPS Centre research suggests five ways:

- GM is not the only biotech solution on offer. Marker-assisted selection and other genomic techniques could enhance conventional breeding through biotechnology. Investment in long-term, local, context-specific breeding and crop development programmes is needed.

- Technologies are never isolated from social, economic and political contexts. The many ways in which farmers manage plants, their soils and the wider environment matter.

- Biotechnology companies are accountable to their shareholders, not the rural poor of the global south. Their business models are focused on widespread adoption of standardised technologies on large farms.

- The ownership of technologies, and the control of their development, matter. Including farmers in priority-setting and upstream technology design is vital. Users of technology understand their own problems best.

- In the face of deep uncertainty, a precautionary stance makes for sound policy. Appropriate regulatory infrastructure is a developing world challenge – each context requires particular regulatory and policy responses based on local evidence. Making technologies work for the poor is inevitably a slow race, resulting in more robust and effective governance. ■

www.steps-centre.org/ourresearch/gm.html

The science of the very small

Peter Dobson looks at the life-changing possibilities created by nanotechnology

NANOSCIENCE AND NANOTECHNOLOGY have become fashionable in the last 10-15 years. Their prominence has spawned science fiction and raised a lot of hope and hype about the possibilities. But what is nanotechnology? Most definitions agree that it is the manufacture of structures that range in size from a few atoms to around 100 nanometres (nm). The diameter of an atom is typically two or three tenths of a nm and a human hair has a diameter of around 100,000 nm. Essentially, we are now able to build new structures from atoms and molecules, a bit like the ultimate Lego. So how is nanotechnology going to affect us day-to-day?

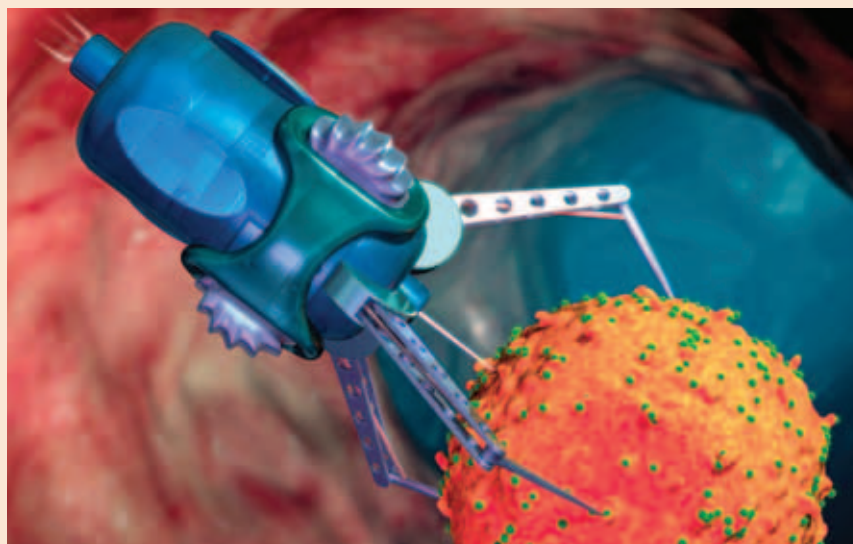
The answers are already out there. Most of the electronics consumer goods that we use today contain many components that have dimensions smaller than 100 nm. The lasers in our CD and DVD players make use of the properties of semiconductor layers that are just a few atoms in thickness, so we really are in the nanotechnology age.

There are many other everyday items that we take for granted that have particles in them that have dimensions smaller than 100 nm. One of the most effective sunscreens on the market uses nanoparticles of titanium dioxide that are doped with the element manganese. This reduces the hazard of its potentially skin-damaging agents known as free radicals. This product is almost transparent to the eye when spread on the skin, and it is effective for much longer than many of the traditional preparations.

This is an example of nanotechnology providing a solution to an existing problem rather than opening up a new product range. In the 1990s there were safety issues with many of the sunscreens in use at the time, and scientists at Oxford University set about finding this solution. This type of technology can also be applied to other goods such as garments, upholstery, paint and plastics, to improve their longevity and safety.

Bearing this in mind, it is interesting to see what some of the world's issues are and to ask whether nanotechnology can help. Climate change awareness calls many things into question. Can we use energy more effectively? Can we reduce the carbon dioxide in the atmosphere? Can we use and purify water more effectively? Can we grow and process food more effectively? Can healthcare be improved? The answer to all of these questions is yes, and nanotechnology can and will provide the solutions. There are few times in history when the application of science to improving the human condition has been so apparent.

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An artist's impression of a nanobot treating an infected cell

We are already making new types of solar cells and batteries using our new-found ability to manipulate matter at the atomic and molecular scale. If we can capture some of the huge quantities of energy that arrive at the Earth's surface from the Sun, and store it effectively, we can reduce the need for fossil fuel-based power stations. We are also using nanoparticles and nanoporous materials to capture greenhouse gases, and we may possibly convert some of them back into fuel. Admittedly, there are still many technical problems to overcome and it will be another decade before some of these ideas are deployed.

Water purification is increasingly challenging and many believe that water, which we take for granted, is going to become more valuable than oil. Currently we do not use water efficiently, and many industrial and food processes leave contamination in water that is potentially toxic and difficult to remove. Nanofiltration may provide the solution to these problems, and may also offer new routes to the desalination of brackish water and groundwater in some parts of the world.

Food production and processing are becoming more important as the world's population increases. There are concerns that potentially harmful nano-products might enter the body via the gut. Such concerns are being addressed, but it's even more important to ask questions about how nanotechnology might increase the nutritious yield of food and be adapted to help preserve and package food. There is already evidence that it can. Nanotechnology is also helping in the primary production of the raw food materials, by way of

better delivery of pesticides in the field and better extraction of protein and carbohydrates.

Healthcare is an area where the application of nanotechnology is already exceeding the expectations of ten years ago. It is happening across several fronts: better appreciation of what the 'natural' nanoparticles circulating in body fluid do; better methods of delivering drugs to the body via nanoparticles that target the diseased body part; improvements to the new diagnostic imaging techniques of ultrasound, magnetic resonance imaging and X-ray computerised tomography. We are now at the threshold of a new subject, 'theranostics', whereby nanoparticles will first deliver the diagnostic information to the clinician and then, using the same particle, deliver a form of therapy.

Nanotechnology is a life-changing technology, making the quality of life better, enabling us to make use of our resources more effectively and creating new business opportunities. There are many other examples in the world of 'new materials' that also make use of this new approach. ■

www.rcuknano.org.uk



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