Synthetic biology
The potential ramifications go far beyond abstract objections to ‘playing God’

Martin Ince, science journalist

IDEAS DON’T COME much bigger than synthetic biology. Its aim is to assemble living creatures to order from component parts, thereby going beyond the haphazard processes of natural selection to produce organisms to a precise specification. Professor Steve Yearley, director of the Genomics Forum, is one of a group of social scientists who are looking at the possible benefits and pitfalls of this massive concept.

As he sees it, synthetic biology raises a range of issues. One is simply the idea that it involves people ‘playing God’. On a more practical level, it could lead to organisms that are unknown on the Earth today being released en masse to the environment. So despite its apparently revolutionary nature, synthetic biology raises the same issues as genetic manipulation, but this time in a more extreme form.

Professor Yearley says that synthetic biology will not be producing novel sharks or cows any time soon. The first objectives are more modest, in the form of bacteria and viruses. They will be made from standard building blocks, initially a few genes in size and later approaching the scale of a whole chromosome, some of which will be available to order off the net.

Synthetic biology’s most noted coup to date has been the work of a group of Californian scientists who have used the method to alter the bacterium Escherichia coli to produce artemisnin, an existing anti-malarial drug. This is a valuable incremental step, but hardly a breakthrough.

Professor Yearley says: “Supporters of synthetic biology such as Craig Venter [one of the leading lights of the human genome programme] say that it will be used to create new energy sources and for other mass applications. That means that the products would be deployed over too large an area.”
to be contained. In addition, we know that bacteria are good at exchanging genes.” So artificial gene sequences may get into existing bacteria.

As Professor Yearley warns: “Humans have already altered the world a lot, but introducing new life forms takes things to a new level. In the past we have failed to spot the effects of our interventions in the natural world in advance, and there is no reason to suppose things will be different here. So public unease about humanity having this power is understandable.”

He says: “Natural selection has produced a wide range of subtle organisms and the idea of recombining them is obviously tempting. It might be possible to make self-replenishing photocells that would produce electricity, or medicines and fine chemicals, or perhaps to make custom-built organisms to remove pollutants. But it is obvious that we need ways of thinking about the ethics of synthetic biology from the start.”

Professor Yearley believes that the answer lies in a proper independent agency that can shape the ethical process for synthetic biology, but adds that the UK currently lacks this sort of technology review body. It would work in an iterative way and take stock of this fast-changing area every few years. There would also need to be global understanding to prevent standards diverging too far. As he points out, the debate on topics such as ‘where life starts’ is very different in Asia from the form it takes in Europe or the United States.

Dr Paul Martin of the Centre for Social and Economic Research on Innovation in Genomics at the University of Nottingham agrees with Professor Yearley that synthetic biology is not so much a complete novelty as a continuation of previous trends such as genetic modification. The difference, says Dr Martin, is that we are now gaining the ability to use robots to synthesise large stretches of DNA. That means new potential but also new hazards, especially to the environment.

One pressure driving synthetic biology is that it might allow new drug manufacturing pathways to be developed, as has already happened with artemisinin. As Professor Joyce Tait explains (page 84), today’s ways of developing drugs take too long and cost too much. But Dr Martin says that it is not clear what synthetic biology has to offer in this sphere. It is more likely to produce new drug manufacturing technology than actual new drugs. As he says: “Science that looks promising in the lab does not always work in real life. Even if it does, the governance structures for medicines are bound to take a cautious approach to anything produced by such a novel and non-natural route.”

Despite these issues, Dr Martin believes that we will be hearing a lot more about synthetic biology. He says: “The term has become attached to something of a bandwagon, a little like nanotechnology. But we know that you need these re-badging ideas if you are going to mobilise resources for a promising new area of science. And after all, the idea of being able to synthesise anything you want from DNA is a powerful one.”

Professor Yearley and Dr Martin are both aware of one major fear about synthetic biology: its possible use to create new weapons. Dr Martin says that governments would be more likely to use synthetic biology than freelance terrorists are. There is a big difference, he says, between making a small but frightening amount of some new biological agent and turning it into a practical weapon. He adds that the methods of synthetic biology might be used to produce new detectors for chemical and biological weapons, helping to reduce their threat.

Professor Yearley warns: “Terrorists or the malicious could in principle use synthetic biology by playing with infectious viruses or bacteria. Even the fear of such a development would be highly disruptive to contemporary societies. The entry costs would be low and the technology is a lot easier than handling plutonium.”

http://www.genomicsnetwork.ac.uk/forum
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The pharmaceutical industry

The pharmaceutical industry is in the news, with items ranging from new cures for diseases or new ways to enhance human performance to risky unintended effects of drugs. And recently, the balance has moved towards more negative coverage, with criticism of the power of multinationals, the high cost of many new drugs, the lack of investment in drugs for diseases that mainly affect the poor, anti-competitive practices, and dirty dealings over clinical trials.

A parallel theme in professional and academic journals is the precarious nature of the research and development (R&D) model for the pharmaceutical sector. The model is widely seen as unsustainable because of thin drug development pipelines and the lack of new blockbuster drugs to generate profits to repay R&D costs. This is the ‘maturity problem’ that eventually afflicts all industries. Effective drugs have been developed for all the easy targets and these are now generic products with low profit margins. It has become increasingly difficult to find new drugs that are effective enough to compete with current products, safe enough to pass the regulatory systems, and cheap enough to manufacture.

Huge investments of public and private money in life sciences have been made to help the industry move on to a new model of drug development with high added value.

**Regulation is reinforcing a situation where current innovation models are increasingly unsustainable**

But while there has been spectacular scientific progress in areas such as stem cells, bio-informatics, systems biology, pharmaco-genomics, nano-biotechnology, bio-imaging, and synthetic biology, this has not yet delivered major new revenue streams.

Despite all the pressures it faces, the pharmaceutical sector has been remarkably resistant to radical change. Over the past 50 years it has changed only incrementally. Over the same period, the information and communications technology sector has experienced several waves of disruption from a series of radical innovations and now bears no resemblance to the industry that existed in the 1960s. Meanwhile for pharmaceuticals, no alternative has yet emerged for the blockbuster drug model, even though most managers now recognise that it is no longer a viable option.

Regulation is probably the most important factor in reinforcing resistance to change. As the regulatory system has built up, development costs have increased so that it now costs up to US$1 billion to develop a product, and can take 12-15 years. No small company can break through this barrier to entry and become an independent multinational, or even a mid-sized pharmaceutical company.

We will never know what new developments have been snuffed out because of these interactions between regulation and innovation. To quote one manager in a small biotechnology company: “I want to be innovative, but not so innovative that I attract the attention of the regulators.” Stem cell science provides another good example. Companies that were initially set up to develop stem cell therapies, which were judged unlikely to be commercially attractive to multinational pharmaceutical companies, are now adjusting their expectations and developing stem cell products for use in toxicology testing for new drugs – which are very attractive to multinational pharmaceutical companies.

So regulation is reinforcing a situation where current innovation models are increasingly unsustainable, but is discouraging new developments that could bring about the necessary change – and tensions are building up within the system.

This is a classic ‘black swan’ situation, as introduced by Nassim Nicholas Taleb in his book *The Black Swan: The Impact of the Highly Improbable*. There is a widespread feeling that ‘this can’t continue’: that the build-up of multiple pressures could lead to rapid, disruptive change. But nobody can predict what might be the eventual trigger for change and what the outcomes will be. Who will be the winners and who will be the losers?

Social science research has improved our understanding of innovation strategies, public-private partnerships, governance and risk regulation in the context of the life sciences. This knowledge could help the pharmaceutical industry to become the first sector consciously to engineer its own ‘black swan’, delivering a relatively soft landing for the industry.

The challenge we face is that of ensuring the safety, quality and efficacy of new products – including drugs – using smarter regulatory approaches that are more responsive to the opportunities coming from the life sciences. There is currently a mismatch between the nature of new life science innovations, the kind of company that can best exploit these innovations, public and patient expectations of new drugs and treatments, and regulatory systems that were designed for 20th century models of drug development.

The key to change is to show how this could be done, rather than merely recognising that it is needed. This would require joint action by industry managers, regulators and a range of other stakeholders with a good awareness of the pressures and opportunities for change.

http://www.genomicsnetwork.ac.uk/innogen
http://www.aecd.org/dataoecd/12/10/40922867.pdf
GENOMICS AND IDENTITY POLITICS
When and how should we apply genomic information to our sense of personal or group identity?

WHAT ROLE SHOULD genomics play in social and political notions of identity? The Genomics Network is undertaking a collaboration across all its centres to investigate the relationship between genomics and identity politics. The research is led by Dr Christine Hauskeller, Professor Steve Sturdy and Drs Gill Haddow and Richard Tutton.

The genome can be seen as the substance that determines what and who a living being is. Genomic testing is increasingly employed to order humans into groups – anything from ethnic or racial identities to families. A person might be a member of a group of patients or disease carriers, or a suspect who becomes identified as a criminal via a process of selecting for deviant groups.

Many people take it for granted that analysis of genomes can reveal the real facts about issues such as sex and gender, kinship, whether someone is a parent, sibling or twin, their status as a patient, future patient or carrier of a genetic disease, their ethnicity and race, their lines of ancestry and biogeographic origin, or, in forensics, their physical presence at a certain place and time.

Genomics is seen as providing certainty concerning aspects of an individual that are considered fundamental in society. Consequently, knowing about a person’s genome offers power over issues such as their health and social position, which is why access and management of such information has become closely regulated.

There are growing commercial markets trading genetically framed knowledge about paternity and health. The making of ethnic identities through gene tests, and subsequent travel packages to visit one’s place or people of origin, sell even better, though the images of ancestry thus endorsed are rather accidental reflections of a person’s ancestors. The singular connection to one of a person’s many ancestors is arbitrary. Many ancestors leave no genomic traces.

The diverse and rich dimensions of a unique individual and the social and bureaucratic need for us to be identified with recognisable and reliable features can be connected via genomic analysis. However, a conviction of the truth and solidity of genomic findings also creates social tensions. Native Americans and First Nation people feel threatened by multiple genomic tests on Y-chromosomes, which show that the three most common male lineages in groups in North and South America originated in Siberia. Their non-American genetic origin could be used to question legal treaties granting land rights on the basis of ethnic origin. Whether and how much we make genomic information matter in any socio-legal context is the cultural challenge genomics has posed.

Native American land rights could potentially be threatened by DNA-based evidence that some ‘indigenous’ peoples actually originated in Siberia.

Genome data has disrupted neat social orders in the notorious confusion about who should be allowed to test for biological kin relations, especially between parents and children. Another disruption was the recent case of a separate ethnic group in northern India with Jewish identity, whose tradition was that they came from Palestine and who were granted the right to move to Israel on the basis of mitochondrial DNA tests that confirmed this historical relation.

Genomic testing can identify a person and their relatedness to other specific people, and is used by various offices and institutions, such as the police, immigration and social services. On DNA-based evidence, people have been reprieved from the death penalty and released from prison, or not charged with child murder in cases of doubted sudden infant deaths, while others have been identified and convicted of crimes.

While the release from death row of unjustly convicted prisoners is surely a successful application, there are other established applications where threats to civil liberties can arise from the use of genomics.

Genomic knowledge has become synonymous with identity knowledge. To unwrap and analyse the complexity and implications of this entanglement is the aim of the Genomics Network workstream.

http://www.genomicsnetwork.ac.uk/events/genomicsandidentitypoliticsworkshopseries
Growing opportunities to facilitate the transfer of knowledge from the scientific community to practical business mean we now have more ‘linked scientists’ spanning the two. They can use their research techniques to investigate important business issues and so provide significant value for business. One way they do this is by participating in collaborative projects. But these activities have their critics, who see this crossover as a form of ‘academic capitalism’, the spectre of ‘profit’ encroaching into the world of academia. Some academics fear that these ties will erode autonomy, result in conflicting priorities and potentially destabilise the research community with a dependence on temporary contract researchers whose employment depends on industry contracts.

Professor Alice Lam of the Science in Society programme, Royal Holloway, University of London, finds that collaborations between universities and business have often proved problematic. One issue is the divergent work patterns of the two and the impact of industrial interaction on the careers of academic scientists. The careers path in academic circles relies on competition with peers pushing scientists to produce good quality science. So what are the benefits for a career scientist in developing links with industry? How does such a person reconcile the requirements of business and still pursue good science?

An example of such collaboration is that of a biomedical research centre that seeks to combine fundamental research with drug discovery. The centre recruited a small team of eminent scientists from industry at the time it was founded. These constitute a core group of ‘linked scientists’ who have brought with them industrial competences and networks. The great majority, however, of the researchers affiliated to the centre have departmental appointments and maintain a disciplinary-based research orientation.

The model of industrial collaboration adopted by the centre is predominantly academic. Academics seek to control the research agenda and the knowledge transfer process. But despite this orientation, the centre has spun off several companies to exploit the new ideas it has developed and to bring in research income. It also collaborates with small biotechnology companies. Until recently, it has consciously avoided collaboration with large companies for fear of losing control, but it is now seeking to forge partnerships with bigger firms.

Another example is a university-industry collaborative research centre for molecular science. This is an archetypal hybrid research organisation situated at the interface between the two sectors, where two-way flows of people and knowledge take place within permeable organisational boundaries. The centre is formally affiliated to an academic department but enjoys a relatively high degree of autonomy. It has one main, though not exclusive, company sponsor with funding provision negotiated on a five-year rolling basis.

The relationship with the company has been sustained by a range of ties including collaborative research, student sponsorships, provision of training programmes, frequent visits and personnel exchanges. These joint activities provide a shared space in which collaboration is managed through the subtle alignment of academic research goals with the strategic interests of the company.

The centre balances academic freedom with industrial interests. Most of the staff are non-permanent researchers and sponsored PhD students. There is a clear framework for the sharing of intellectual property rights, but younger researchers are shielded from commercial activities such as patenting to ensure that their training is consistent with educational goals. This model provides an environment for joint knowledge production and the development of linked scientists.

But for a hybrid organisation that spans institutional sectors, the task of maintaining a stable co-operative dynamic is an ongoing challenge. Despite its strategic importance in generating research resources, the centre’s status remains secondary to that of the host department, which continues to maintain control over appointments and promotions. The lack of stable funding and employment is another common source of organisational tension.

The third example is that of a university-based biotech spin-off firm. Its operation is closer to that
Historically, left-handedness has been associated with being clumsy, defective—even evil. In the 1960 to 1980s studies in medicine and psychology found left-handedness to be associated with a range of disorders including autoimmune problems, depression, delayed physical maturation, learning disabilities and delinquency. Yet in popular discourse left-handedness is often associated with creativity, and two recent studies, one in the United States and one in Britain, have found that left-handed men earn more than right-handed men. Given this intriguing finding, Professor Paul Gregg, Katharina Janke and Professor Carol Propper from the Centre for Market and Public Organisation set out to investigate whether left-handedness for contemporary children, for whom handedness is no longer a source of stigma, was associated with differential cognitive development, a well-known predictor of later earnings. They analysed data from the Children of the 90s study, which has data on over 10,000 children. It contains clinical measures of handedness and has been matched to data on each child’s performance at school on national tests. The results of national Key Stage 1, 2 and 3 tests, taken at the ages of seven, 11 and 14 respectively, and an IQ test, were used to find that left-handed children perform slightly less well in terms of the IQ test and the Key Stage 2 and Key Stage 3 tests. The rich nature of the data meant that the researchers could rule out other factors that might have caused a gap in cognitive development—for example, being from a poorer home background, family size, parents’ handedness and child’s birth weight. In addition, there is no evidence that the gap in cognitive tests diminishes as children age. But the size of the effect is modest. A typical left-handed child has test scores one per cent below those of their right-handed contemporary.

So while left-handedness is perhaps no longer seen as deviant as it once was, operating in a right-handed world still leaves left-handers behind in the literacy and numeracy tests, and these gaps do not diminish as children age. This leaves the question of why male adult left-handers earn more than their right-handed contemporaries.


AT A GLANCE

Left-handed children do less well in national tests than their right-handed peers, and the gap does not diminish with age. So why do left-handed men make more money as adults?
PEER EFFECTS IN SCIENCE: EVIDENCE FROM THE NAZIS

On seizing power in 1933, the Nazi government dismissed all Jewish and ‘politically unreliable’ scholars from German universities – roughly a fifth of all scientists. Fabian Waldinger of the Centre for Economic Performance has used data on this event to measure ‘peer effects’ in science – the degree to which scientists are more productive when surrounded by able colleagues.

It’s not easy to estimate the extra productivity of a scientist that comes from their peer group. The top departments might have the best staff but they also recruit the brightest prospects, which makes it hard to determine how much of a scientist’s success is down to the calibre of their colleagues. But because the scientists in Nazi Germany were not dismissed on the basis of their ability, and because some departments lost more than half their personnel while others lost none, this incident offers a perfect natural experiment.

The impact was that researchers in affected physics departments experienced a dramatic loss in numbers of peers and average peer quality as measured by academic citations. Researchers in departments without dismissals did not experience big changes in either the number of peers or quality.

Waldinger finds that the productivity of researchers in the affected departments did not suffer from the dismissal of their colleagues. But if a researcher was dismissed, the productivity of their co-authors declined by between 11 and 14 per cent as measured by citation-weighted publications in top journals.

Does any of this matter now? While it may be that department-level peer effects are less important nowadays as communication costs have fallen, the same need not apply to effects among co-authors. Peer effects among co-authors may well have grown since the early 1930s as co-authored studies have grown in importance with increased specialisation and more ‘big science’ projects.

So it doesn’t seem necessary to make sure that the best researchers work in the same departments to increase their scientific productivity. But what does seem important is improving the possibility of co-authorships by increasing academics’ exposure to other scientists with similar research interests from around the world.

http://personal.lse.ac.uk/waldinge

SOCIAL SCIENCES HELPING TO SOLVE ANIMAL AND PLANT DISEASE

Controlling pathogens by studying human activity

What do the social sciences have to offer when it comes to tackling animal and plant disease? Surely that’s a job for biologists, probably wearing white coats? But many animal diseases also infect people. Some strains of E coli are harmless to the cows that normally harbour them, but are life-threatening to children and vulnerable adults. Lyme disease is spread by ticks from wildlife, often deer, to people in the countryside.

So we don’t just need to know about pathogens. It is also vital to understand how humanities behave. The Rural Economy and Land Use (RELU) programme includes multidisciplinary projects looking at a range of these issues. As people move from one continent to another more freely and trade goods in the global economy, Britain can no longer expect to remain free of endemic diseases. Understanding ways of reducing this risk is more important than ever and social science research has much to offer.

Campylobacter, which is often found in chickens, is one of the commonest causes of diarrhoea in humans. Professor Richard Shepherd at the University of Surrey and his research team are looking at the risks of being infected by this pathogen. They have designed new ways of involving consumers in modelling the food chain, using computerised ‘fuzzy felt’. This is a simple way of helping non-scientists to map and understand the

Brave new world of psychiatric genetics

To some, the rebirth of psychiatric genetics is an anathema to the lessons of history. The eugenics movement, the anti-psychiatry movement, the critique of twin studies and IQ testing, and the failure to replicate the ‘gene for’ homosexuality and schizophrenia are all warnings that biological reductionism offends the core principles of liberal society. Then along came the Human Genome Project.

Current research, led by Dr Michael Arribas-Ayllon at the Centre for Economic and Social Aspects of Genomics, on psychiatric genomics comes as understanding the complexity of the science involved could not be more significant. The genomic revolution has astounding potential benefits. Rather than reacting to manifestations of disease, genomic medicine
sources of risk. They find that improving the way people handle and cook chicken can reduce their risk of falling ill.

Social science is even important in controlling animal diseases that don’t infect people. The 2001 outbreak of foot and mouth disease did not only affect animals: it also cost an estimated £8 billion and had serious consequences for the rural economy. Its diagnosis and management depend on people, because moving animals and vehicles spread the disease. So we need to understand human behaviour to reduce the risk.

Professor Graham Medley from the University of Warwick is leading a team of researchers who are looking at animal diseases, and especially at how government policies on dealing with them interact. Thus we know that during the foot and mouth outbreak, testing for bovine tuberculosis almost ceased, as resources were taken up with the new epidemic. Then the restocking after the foot and mouth outbreak spread bovine tuberculosis into areas that had previously been free of it.

Social science can also help us to tackle plant disease. In the 1970s many people were saddened by the loss of valued landscapes to Dutch elm disease. But in some parts of the country, local responses were more effective. Another RELU project, led by Dr Clive Potter at Imperial College, is investigating how our experience of that epidemic might help us in tackling new threats to our native flora, and how much we might be prepared to pay to protect this natural heritage.

http://www.relu.ac.uk

Understanding human behaviour will help reduce the spread of animal and plant disease.

Will become a truly active and personalised medicine. Disease can be diagnosed, treated and prevented before it occurs. Drugs can be tailor-made to a person’s genotype; a person’s genome can be scanned to identify every kind of susceptibility. Biological psychiatrists are even scanning the human genome to unlock the secrets of common mental illness.

Genomics means that scientists are no longer divining simple solutions from complex biological problems. They are arriving at solutions that are equally complex. The genetics of common psychiatric disorders are so multidimensional that risk prediction must account for interactions between genes and between genes and the environment. Factors that were once absent from genetic models, such as stress, environment or poverty, are now incorporated into the models.

The recent launch of psychiatric genetic testing in the United States has attracted controversy as scientists and entrepreneurs tap into the lucrative market for personalised medicine. You can now order a test online for schizophrenia and bipolar disorder, and have the results explained by a GP.

Is the business model selling complex science? Not really. What these companies are selling is the detection of single genes of major effect. This is simple Mendelian inheritance dressed up as cutting-edge research, and has poor predictive value. Sophisticated methods of genome scanning are used to locate genes, but the business model assumes that detecting one gene is more informative than the use of existing methods in psychiatry. This raises important questions about the untimely promises of the bioeconomy, the burden of interpreting risk information, and its effect on already ambivalent consumers.

Research in Britain is currently examining genomic psychiatry and its impact on mental health care. One fruitful line of inquiry is tracing how genetic reductionism weaves its way through the bioeconomy. The research focuses on developing a critical understanding of how current ways of knowing our genetic futures can be out of step and time with the promises of risk prediction in the era of the genome.

http://www.genomicsnetwork.ac.uk/cesagen
QUESTIONING THE TREE OF LIFE

Alternative ways of representing evolution

Scientists and historians are gearing themselves up for Darwin Mania. In 2009 it is 200 years since his birth, and 150 years since the publication of *On the Origin of Species*, the work that introduced Darwin’s theory of evolution. The work also introduced Darwin’s speculations on the ‘Tree of Life’, a way of representing the evolutionary relationships between the diverse lifeforms on Earth.

All through the last century, and into this, the Tree of Life has continued to be used as the central representation of these evolutionary relationships. The Tree of Life Web Project, for example, is a collaborative effort by biologists to “provide information about the diversity of organisms on Earth, their evolutionary history and characteristics”.

“The Tree of Life purports to represent the true evolutionary relationships amongst organismal lineages as a single, ever-bifurcating pattern,” says Professor John Dupré, Director of Egenis, the Centre for Genomics in Society. “Huge databases of genetic data have consolidated the research as an international scientific project with the aim of resolving the branching order of the tree.”

Yet not all biologists or philosophers of biology agree that the Tree is the best way of thinking about evolutionary relationships.

The issues, says Professor Dupré, are that:

“Underlying these global research aims are some major assumptions about evolutionary relationships and their depictions. Many of these assumptions may be unwarranted. In the last several years, the increased availability of molecular data from many organisms, especially microbes, has thrown traditional assumptions about vertical descent in particular into disarray.”

Researchers from Egenis are creating an international network to explore representations of evolutionary relationships between organisms, particularly how microbes interact genetically with one another and with the rest of life.

The network will connect currently separated perspectives, clarify the assumptions of Tree of Life thinking, examine the possible alternatives, and develop philosophical approaches to novel ways of thinking about and representing the evolution of organismal lineages.

Participants include Professor Ford Doolittle, who has long been known for his radical interpretations of microbial evolution, and Professor Elliott Sober, one of the world’s most distinguished philosophers of biology.

http://www.genomicsnetwork.ac.uk/egenis/research/sciencetechnologyandinnovation/

Talking in science classrooms

IN THE SCIENCE classroom, it is traditional for teachers to ask questions and for students to answer. What is less expected is a dialogue.

A team led Professor Neil Mercer of the University of Cambridge and Professor Phil Scott of the University of Leeds carried out analysis of the talk between teacher and students in science lessons. They looked at ‘dialogic teaching’ as the art of stimulating students to think, learn and understand. Such classroom talk is not just chat, but a highly disciplined technique to lead students in learning. It is very different from the ‘question and answer’ or ‘listen and speak’ approaches, and from the rote method of repetition, which focuses on memorising rather than understanding.

Questioning is a part of life, but students learn better when they are challenged and made to think about the question and how it relates to what they know, rather than just having to provide the answer.

Asking questions to ascertain a student’s understanding, followed by challenging them to think further by asking ‘why?’ is one tool teachers can use to help guide a student’s reasoning. But true dialogue has a vital role alongside question and answers. The dialogic approach encourages children to share their ideas and develop their own understanding. It encourages them to make a significant contribution to the class, allowing them to articulate, discuss, reflect, and modify their ideas and so contribute to their learning.

In this method of teaching, the teacher finds out what students already know, encourages participation from the whole class, listens to students’ ideas and contributions, allows time for students to talk and think together, and guides the dialogue towards relevant conclusions.

http://www.educ.cam.ac.uk/people/staff/mercer
HIGHLY EDUCATED parents responded more strongly to the controversial study linking the measles, mumps and rubella (MMR) vaccine to the development of autism in children. That is the central finding of research by Professor Dan Anderberg, Dr Arnaud Chevalier and Professor Jonathan Wadsworth of Royal Holloway, University of London.

What’s more these parents were less likely to have their children vaccinated against other diseases after the controversy, not just MMR. Since there was never any suspicion of doubt about other vaccines, this may have put the health of their children at even more risk than missing the MMR vaccine.

The publication of medical research linking the MMR vaccine to autism in *The Lancet* in February 1998 sparked a decade-long controversy about the triple jab. Following the initial publication, the uptake rate of the MMR vaccine dropped from 92 per cent in 1997/98 to 80 per cent in 2003/04.

The research by Professor Anderberg and his colleagues examines how the response to the MMR controversy varied between parents with different levels of education. Before 1998, highly educated parents were up to eight per cent more likely to take up the MMR vaccine than parents with lower education. By 2002, this gap had not only closed, it had been reversed, with highly educated parents being two to three per cent less likely to accept the MMR vaccine.

Most of the relative decline in the MMR uptake by highly educated parents occurred soon after the controversy broke, when media coverage of the subject was still relatively low. After the increased media attention in 2001 and 2002, there were no discernible differences in trends between educational groups. The controversy also appears to have had effects on the uptake of other childhood vaccines: after 1998, highly educated parents also reduced their relative uptake of other, ‘non-controversial’ childhood vaccines.

The original research published in *The Lancet* described a set of bowel symptoms and suggested a link to autism. The study included eight children whose parents said they had developed normally until they were given the MMR and had then begun to regress. Dr Andrew Wakefield, the lead researcher, suggested that children should be given the three vaccines separately, rather than the combined MMR jab.

In the following years, a substantial body of research failed to verify any link between the vaccine and autism, and successive research reviews concluded that the vaccine was safe. The controversy nevertheless led many parents to worry, and the MMR uptake rate fell far below the 95 per cent immunity rate required to stop measles from being able to spread.

The new research uses data on the uptake of immunisations collected at the Health Authority area level, which the authors combine with population characteristics from the *Health Survey for England*. They also use data from the *Millennium Cohort Survey*, which contains information on 8,000 English children due to obtain the MMR at the height of the controversy. That more educated parents had a lower uptake rate at the peak of the controversy is remarkable. More highly educated parents are usually likely to vaccinate their children.

It also has potentially wider significance. Generally speaking, individuals with more education have better health. This is possibly because they are better informed about how to achieve better health outcomes. The finding that highly educated parents were the first to react to the information that the MMR had potential side effects is consistent with this hypothesis.

More puzzling is the finding that highly educated parents also reduced their uptake of ‘non-controversial’ childhood vaccines. One explanation for this is that these parents had reacted to the ‘overload theory’, which states that ‘too many’ vaccines, and multi-component vaccines in particular, could potentially be harmful to infants, a theory expressed at the time by Dr Wakefield.

http://econpapers.repec.org/scripts/search.asp?ft=MMR+controversy
Human beings are social animals, and in many ways our society is increasingly interconnected. With population on the rise and communication technologies booming, an average person’s average day can include hundreds of social encounters, from fleeting glances to hour-long phone calls. This degree of interconnectedness can be tremendously enriching, but there is a downside. Every opportunity for communication carries a risk of miscommunication, which turns out to be surprisingly important. Subtle signals from the face or voice have the power to shape economies and influence electoral outcomes.

Take facial appearance. Experiments show that within a tenth of a second of seeing a face, we have already made up our minds about its owner. Extra time can shore up our initial impressions, but tends not to change them. And these snap judgements have all sorts of unforeseen consequences in the real world. Inferences of competence based solely on facial appearance have been shown to predict the outcomes of US congressional elections. Dominance ratings of chief executives’ faces can predict their companies’ profits.

The implication is that supposedly responsible decision-making can be hijacked by people’s looks. Add voice and gesture to the mix, and what emerges is a rich and seemingly irresistible body language that can influence our behaviour without our knowing it. First impressions last a long time indeed – a sobering thought to take with you into a job interview, not to mention a court appearance.

Impressions are mainly formed unconsciously. To identify the steps involved, we must turn to the ultimate engine of social interaction, the brain itself. Our smooth running requires us to grasp complex situations in the blink of an eye. Is this person hostile? Does she know that he is lying? When should I interrupt? How the brain resolves such dilemmas is not yet fully understood. But recent advances in neuro-imaging offer a direct window onto brain activity.

The view is fascinating, and full of surprises. For example, our impressions of other people originate in primitive emotion centres deep inside the brain, in evolutionarily old circuits that regulate fear and reward. These circuits are highly sensitive to facial expressions of emotion. The merest hint of a smile or frown is enough to set them off. The upshot is that even a neutral expression can activate these circuits, if the underlying features suggest a certain disposition. So if your mouth turns up at the corners, people may tend to regard you as trustworthy. If your brow is naturally furrowed, however, you may arouse suspicion.

We might think of emotions as strictly private, but emotional responses to emotional expressions give brains a powerful coupling mechanism. This means that mood can be highly contagious. Try listening to the clip at http://www.bbc.co.uk/programmes/f0267g80/audio/legover.mp3 without smiling. You’re doomed to failure, but it will make your day.

Behaviours can also be contagious. Perhaps the most familiar example is contagious yawning, where one drowsy indiscretion can set the whole room off. This phenomenon is often regarded as a one-off, but in fact social interaction is shot through with mimicry. Conversational partners follow each other’s gaze, and unwittingly align their accents and mannerisms. Over decades of companionship, spouses converge visibly in their physical appearance.

On shorter time scales, unconscious mimicry has implications for co-ordinating joint actions. Co-ordinated movement often requires millimetre precision and split-second timing, but it also demands responsiveness to other people, their actions, and their goals. Somehow, this complex behaviour comes as second nature to us. But group cohesion can be fragile. Co-ordination can spell the difference between a Mexican wave and a crowd panic.

So who stands to benefit from social interaction research? Broadly speaking, people who communicate. In our personal and professional lives alike, good decisions depend on effective communication. But what people say is not always what they think. It is often body language that carries the important message. Some people have difficulty reading body language, and this can hold them back in social settings. This pattern is typical of autism. One long-term goal of our research is to help decode body language and identify the building blocks of social fluency for use in practical training.

There are also clear technological applications. Mobile phone and computer industries have a particular interest in tapping supplementary channels of communication to support speech and text. Current communications technology leaves many users feeling cold, but building social signals into machines could help to restore the human touch.

Despite these potential beneficiaries, it is arguably the economy that has most to gain. 2008 saw unprecedented turmoil in global markets. Banks failed, markets collapsed, and governments scrambled to avert meltdown. And significantly, world leaders were united in their prescription for recovery: trust, confidence, and co-ordinated action.

http://www.socialinteraction.gla.ac.uk