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re:search

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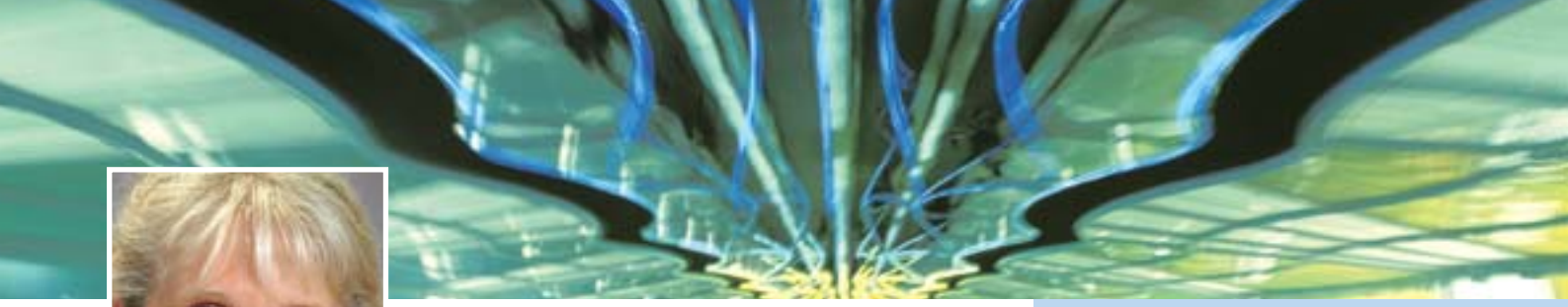
Sons of blacksmiths and nematode worms

Sordid stories of domestic violence

Futuristic fridges



The Writing Competition

The University is committed to making the results of its research as widely available as possible to the general public. One way we do that is through the pages of this magazine, but it isn't always easy to find material. As an incentive to encourage more articles, we devised a writing competition.

The brief was simple: write about your research in less than 1,000 words and if the title grabbed our attention, the content enticed us to read on, and if we didn't need a jargon-dictionary to understand it, then you might win a cash prize to spend on your research.

The reality was more worrying. The day before the deadline we had precisely two entries. Didn't anyone else want a share of the £1,000 prize? But I should have known everyone would leave it till the last minute. Overnight there was a flood.

And then the tricky bit began. The standard was high. The subject-matter varied. How do you compare an article on celebrities with another about bacteria? No-one on this planet can escape knowing what a celebrity is, but has everyone heard of *E. coli*? And does that make the former easier to write about? Maybe, maybe not, but it certainly made the judges' task very challenging.

We read them all, we deliberated, we read some again. In the process the best emerged and, thankfully, we were all in agreement. Here you can read our choice of winners. You may not have put them in the same order as we did, but one thing is certain – they all make great reading.

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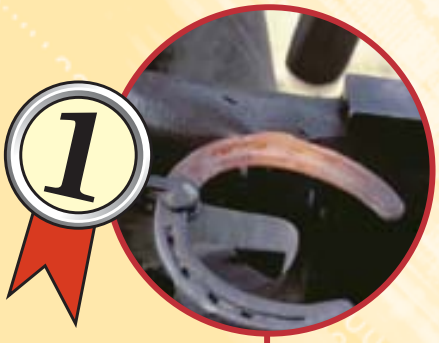

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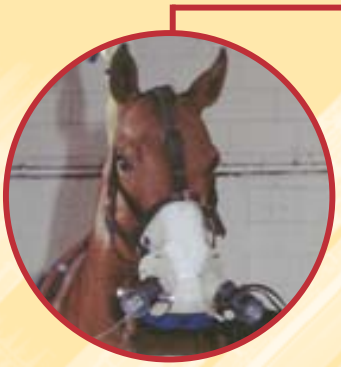

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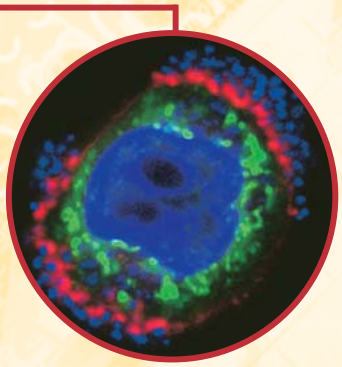

Runner-up

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First
Dr Simon Harvey, Research Associate,
School of Biological Sciences

Lamarck's blacksmiths and the worm's genes

In the late 18th and early 19th centuries it was observed that the sons of blacksmiths tended to have larger and stronger arms than the sons of weavers.

Now, if you asked a biologist to explain this observation today, you'd probably get a series of questions such as who observed this? where did they grow up? what did the mother look like? what is the sample size? or even, can we swap the children at birth? If you actually got an answer, it would probably focus on differences between the children in their patterns of diet and exercise, and on the effects of a higher quality diet and harder physical work on the growth and development of the sons. However, when presented with this observation about the blacksmiths, biologists of the 18th and 19th centuries came to a quite different conclusion.

It was, in fact, observations of situations like this that led the French scientist Jean-Baptiste Lamarck to develop a theory of the inheritance of acquired characteristics. This theory relied on two rules. The first rule stated that organisms responded to their environment by changing the way that they used a particular structure or organ, and that in response to this change in use they physically adapted to become better suited to their environment. The second rule said that these environmentally induced changes were inherited and, as such, would be passed on to the children. Accordingly, under this theory, blacksmiths exercised their arms as they worked and therefore developed big muscles, a trait that was then passed onto their sons.

Until the start of the 20th century this theory of evolution, which eventually came to be called Lamarckism, remained a popular alternative to Charles Darwin's now widely accepted theory of natural selection. Given that at this time scientists had no idea about the mechanisms of genetic inheritance, apart from a then obscure Augustinian monk by the name of Gregor Mendel, Lamarckism was actually a pretty good theory and was just as plausible as Darwin's. However, there is a small problem with it: today we know it to be completely wrong. If it were correct, that individuals passed on to their offspring changes they have undergone in their lifetime, then children would be born with pre-pierced ears and the children of body-builders would not bear thinking about. ➜

➜ So, what has all of this got to do with worms? More specifically, what does this have to do with my work on the small invertebrate nematode *Caenorhabditis elegans* that I spend my time working on?

Aside from the fact that Lamarck invented the word invertebrate, while Professor of the Natural History of Insects and Worms at the French National Museum of Natural History, there is a more interesting biological link between the worm and Lamarck's theory. If we look again at Lamarck's two rules, it is apparent that it is the second one that really gets his theory into trouble, since the kind of changes he was considering are just not heritable. However, this still leaves the first rule – that organisms respond to their environment by changing to become better suited to that environment. The muscles of the blacksmiths and their sons are responding to their environment, and although this represents a quite trivial example of such an interaction between an organism and its environment, the phenomenon is widespread and there are many fascinating examples to be found in nature. For example, *C. elegans* has a quite striking interaction with its environment, such that under conditions unfavourable for growth and reproduction, instead of developing into an adult it can go into a form of stasis, developing into an arrested stage that is both environmentally resistant and long-lived. Once environmental conditions improve, the 'arrested' worm resumes development, growing into a perfectly normal adult.

Developmental switches like this are relatively common among nematodes and it is perhaps unfortunate for Lamarck that, limited as he was to studying preserved specimens, he could have had no idea about the varied and complex life-cycles of his worms. It would be interesting to know what influence such knowledge would have had on the development of his theory of inherited characteristics. Biologically, such an interaction between an organism and its environment is termed 'phenotypic plasticity'. This represents the ability of a particular individual to show one set of characteristics if it develops in one environment and a different set if it develops in another environment.

At present the genetic and molecular basis of any example of phenotypic plasticity is not known. However, it is hoped we can change that through analysis of the switch between normal and arrested development in *C. elegans*. This hope relies entirely on our understanding of the mechanism of inheritance, thanks to Gregor Mendel, and on the extensive existing knowledge of the biology and genetics of *C. elegans*. Identifying the particular genes that control this plasticity in our worm's life-cycle is of great importance as, even with thousands of people studying it, a significant proportion of the genes that go into making our worm are complete mysteries. The completion of the human genome project has revealed a very similar situation – thousands and thousands of predicted genes about which we know nothing. Since relatives of many of these unknown human genes are also present in *C. elegans*, studying the worm will help us to work out what some of these unknown human genes do.

Additionally, it's nice to think that some of the work currently being done on one of Lamarck's invertebrates may lead to him being remembered with greater fondness. After all, Charles Darwin and other early evolutionists acknowledged him as a great zoologist and a forerunner in the study of evolutionary biology – as indeed he was. ■

Charles Darwin acknowledged Lamark as a great zoologist

Simon will spend his £500 prize on attending the 2005 International C. elegans meeting in America. This work was supported by the Natural Environment Research Council.

Adult hermaphrodites of *C. elegans*
Simon Harvey

Second
Dr Edward Forman, Senior Lecturer in French,
Department of French

Excuses, excuses… tragic guilt and

"Female shall murder male: what kind of brazenness Is that?"

Æschylus (~458 BC), *Agamemnon*

"Vous savez, avec un bon avocat, quand on plaide le passionnel …" ("Well, you know, if you get a good lawyer and say it was a crime of passion …")

Jean Anouilh (1969),
Tu étais si gentil quand tu étais petit

In July 1995 Emma Humphreys was released from prison. She had killed her partner Trevor Armitage in 1985, but after ten years her conviction for murder was overturned in what was widely greeted as a 'landmark' ruling. It was the first time English courts had accepted a defence of provocation – as grounds for a conviction for manslaughter rather than murder – where the killing had been triggered not by a single explosive event, but by a series of incidents which gradually drove a female victim of bullying to turn on her male tormentor. After this case, juries and judges could take account of the cumulative effects of long-term violent mistreatment, and could do so even if those effects included incidents in which the eventual killer fantasised about or publicly threatened revenge, so that it was a very delicate judgement as to whether the killing resulted from a temporary loss of control or was the realisation of a plan. On the evening of his death, Armitage had incited two other men to rape Humphreys, threatening to beat her up if she resisted, and had then taunted her as she contemplated suicide. She stabbed him to death with a knife with which she had previously been attempting to slit her own wrists.

Three thousand years before this case was considered by the English Court of Appeal, King Agamemnon returned home from the Trojan War. He had lived a violent life in a bloodthirsty age: he married Clytemnestra after killing her former husband, his cousin Tantalus; he assented to the ritual sacrifice of their daughter Iphigeneia as the cost of success in Troy; during and after the expedition he openly lived with concubines Chryseis, Briseis and Cassandra, treated exploitatively as the spoils of war. Clytemnestra had long found consolation for her husband's absence in the arms of another of his cousins, Ægisthus, and greeted his return, unsurprisingly, with bitter resentment rather than joy. Luring him with false expressions of relief and pleasure into a bath, she killed him.

What is the relationship between these two sordid stories of domestic violence? Should the judge or the jury, in considering the case of Emma Humphreys and others like her, have been subjected to the influence, or the challenge, of Clytemnestra, as she has been presented in tragedies, from Æschylus to Eugene O'Neill? Her case is not a legal precedent, but does it contribute validly to the ethical framework for a modern legal decision? When sociologists coin terms like 'battered woman syndrome' or 'learned helplessness', and use them to extenuate violent responses, what can they learn from classical tragedy? – and can they in turn influence the æsthetic effectiveness of art and literature from the past, by opening up new perspectives on archetypal human situations, based ➜

What is the relationship between these two sordid stories of domestic violence?

extenuation

→ on contemporary experience? This sort of interaction between the ancient and the modern is particularly relevant in the study of performance, since an actress playing Clytemnestra – or Medea or Phædra – on a 21st-century stage will only affect her audience if she conveys both the permanent importance of her distress and its immediate urgency.

Research and scholarship in the Arts and Humanities is seldom a matter of inventing new things, but it does involve a quest for fruitful new ways of seeing the familiar, of making an artistic or literary heritage relevant to new audiences, and of exploring relationships in unexpected areas. The case of Clytemnestra is one of several which I have been exploring in a study of tragedy – Classical, French, Shakespearean and modern – in relation to the theme of extenuation and mitigating circumstances (or, as the more jaundiced might call them, mere excuses). The definition of tragedy has always been very slippery, and may even give rise to the sort of debate over terms which gives academic research a bad name. For me, tragedy is characterised by its exploration of areas of moral ambiguity, where the protagonists feel responsibility, guilt and shame, but where more detached observers are aware of extenuating factors. As a result, tragedy raises awkward and deep questions about the justice of a universe in which misdemeanours, miscalculations or errors of judgement are followed by disproportionate retribution.

Examples abound from all periods of tragic drama. Would a modern Medea get away with manslaughter on the grounds of diminished responsibility? Was Macbeth suffering from post-traumatic stress disorder? What does the genome project tell us about Hamlet's feelings of helpless insecurity? Should Œdipus at Thebes have made more of his defence of ignorance, as would the shamed and ashamed communists scathingly described, thousands of years later, in Milan Kundera's *The Unbearable Lightness of Being?* Could Willie Loman in Arthur Miller's *Death of a Salesman*, or Stanley Kowalski in Tennessee Williams's *Streetcar named Desire*, have done anything, or at least more than they did, to escape from the peer pressure that led them inexorably from the American dream into the American nightmare?

By investigating these potential excuses for shameful action, in law, in ethics and through the worked examples provided by tragedy, I hope to be led both towards new insights into the nature of human responsibility and towards a re-evaluation of the power of performance art to help us assess human behaviour with justice and compassion. ■

Edward will use his £300 prize to fund a study trip to Paris and other French theatres, where production traditions of the works he is interested in are often interestingly different from British equivalents.

Joint Third
Dr Laurence White, Research Associate,
Department of Experimental Psychology

Itisnotsoeasytoreadifallthewordsareruntogetherwithoutspacescommasorfullstops. Listening to an unfamiliar language can be similarly troublesome, sounds following each other rapidly with no clear start and end to words. In contrast, listening to speech in your native tongue is so effortless that it can seem like successive words are separated in time, like words on a page broken up by white spaces. In fact, silences between spoken words are relatively uncommon. So – how do we find the gaps?

Making sense of speech: it depends on how

Fishing the individual words from the onrushing stream of speech sounds is known as 'speech segmentation'. This is a fundamental aspect of human language processing, essential from an early age. If babies could not learn to separate words from the babble of voices they experience, they would never develop an understanding of complex speech or the knowledge necessary to produce the words for themselves.

a number of acoustic markers that guide listeners to the location of word boundaries. Word stress – which underlies the rhythm of speech – is one such segmentation cue; variations in the length and quality of speech sounds at word boundaries are also important. How the various cues are exploited when encountered in combination in real-life speech has remained something of a mystery, however.

Our cross-modal priming experiments show that when speech is clear and listening conditions are good, listeners use the meaning of what they have already heard to generate expectations of what is coming next. To take an extreme example – hearing "The cat sat on the …" you are likely to have little trouble picking out the following word "mat". This is one reason why knowledge of a language is so important – a non-speaker of English,

Take an extreme example – "the cat sat on the…"

There are various experimental tools available to speech segmentation researchers. One rather indirect, but powerful, technique exploits the fact that a written word is recognised more quickly if the reader has just heard a fragment of the same word. This effect –– cross-modal priming – is a sensitive gauge of what listeners have extracted from speech. Using such techniques, psycholinguists and phoneticians have been investigating speech segmentation for decades, identifying

Research in the Experimental Psychology Department, by Sven Mattys, James Melhorn and myself, now suggests that the human speech processing system takes a flexible approach to speech segmentation, according to the amount of information available at any moment. Essentially, the segmentation strategy is two-pronged, tackling the problem from the top down (from the meaning of the message) and from the bottom up (from the actual sounds of speech).

hearing the same sequence of sounds, would struggle to identify the breaks between words that the context makes so obvious for a native speaker. Clear context allows listeners to exploit their existing 'top-down' knowledge of language, but not all speech is so predictable, of course. Often the context created by the preceding speech is ambiguous or the speech signal itself is muffled by the talker or by background noise. Our research simulates this variability in speech ➜

you slice it

→ quality to examine the segmentation strategies that we fall back on when we have incomplete information.

Not all languages exploit the same cues as English

A range of cues comes into play when top-down strategies cannot operate. Knowledge about likely sound sequences within words – phonotactics – is a valuable source of information. For example, there are no native English words beginning "shl" but plenty beginning "sl", so listeners find it easier to hear "lake" in "dish lake", where the "sh" must belong to the previous word, than in "kiss lake", where "sl" could itself be the start of a word onset. In addition to these phonotactic cues, sounds at the start of words are often produced slightly differently and may be lengthened, patterns that listeners become familiar with at an early age.

When the noise level is such that individual sounds cannot be reliably identified, speech rhythm becomes important. The majority of words in English begin with a stressed syllable, such as the first syllable of "spoken". Because of this, a useful fallback strategy in difficult listening conditions is for listeners to treat all stressed syllables as the start of new words.

Always using stress to find word boundaries would lead to a lot of mistakes, however, because many words do not begin with stressed syllables. Chinese whispers tend to follow this pattern, so that "a chief in the pendants" might be the perplexing interpretation of "achieve independence", with word boundaries placed before the stressed syllables. Our research demonstrates that listeners ignore stress patterns when there are more reliable segmentation cues available.

Not all languages exploit the same cues as English to guide listeners to word boundaries. If they did, we would have a big head start in language learning, being able to pick out the individual words even without knowing their meaning. We are now beginning to examine speech segmentation in other languages, looking particularly at the intriguing question of how someone's first language affects their ability to learn another. Languages with similar segmentation cues, like English and Dutch, may promote mutual learning more than languages like Italian and Hungarian, which seem to have widely differing word boundary markers. If you struggled with French at school, this research may provide you with a belated excuse! ■

Laurence's £100 prize will help support research travel abroad to broaden the scope of the next phase of the project: investigating speech segmentation in other languages. This work was supported by the Biotechnology and Biological Sciences Research Council.

Joint Third

Dr Tom Mole, Leverhulme Early Career Fellow,
Department of English

Are celebrities a thing of

Lord Byron

I was in Boston last week for a cultural studies conference, and one of the papers caught my eye. The event had been bursting at the seams with odd poststructuralist analyses of *Buffy the Vampire Slayer*, but this paper was surely the oddest of the lot. It was called 'Zsa Zsa Gabor's Persona as an Aging Celebrity'. I was in Boston to talk about celebrity myself. I've spent the last five years investigating the history of celebrity culture – especially the poet Lord Byron – and I was there to tell people what I've discovered, but I wanted to take the long view. While Zsa Zsa's certainly not getting any younger, celebrity culture is even older than her. Two hundred years older, in fact.

Celebrities are everywhere now, but hardly anyone thinks to ask difficult questions about how celebrity culture works, and where it came from. The few who do ask have tended to fix on film, tracing celebrity culture back to the rise of cinema in the early 20th century. I think they're right to link celebrity to a new technology, but they've got the wrong one. As a literary scholar, I can see that the crucial technology was printing, and that the enabling advances took place a century earlier.

Printing and publishing became a full-blown industry at the end of the 18th century. That led to a massive growth in the number of books published and fuelled the rise of newspapers, magazines and advertising. At the same time the audience for those texts expanded as the population grew and more of them learnt to read. In the early days of industrial capitalism, this produced a rich and fascinating print culture. But it also created two new problems.

Firstly, people started to suffer from information overload. Isaac D'Israeli was already swamped by 1795. Since "every literary journal consists of 50 or 60 publications," he wrote, "when I take the pen and attempt to calculate … the number of volumes which the next century must infallibly produce, … I lose myself among billions, ➜

the past?

→ trillions, and quartillions". At the same time, the percentage of books published anonymously dropped drastically. As more and more named authors jostled for public notice, a personality overload set in. Readers couldn't possibly keep up. They needed ways to select which texts to read and which to ignore. Secondly, readers and writers started to feel alienated. In the new mass market for books, they could no longer know each other. The audience became a faceless crowd, while the author risked being a distant and impersonal figure. Writers and readers started to feel like estranged producers and consumers in the marketplace.

Celebrity culture emerged to solve – or at least to mitigate – both those problems. In response to the personality overload, it turned the celebrity's proper name into a brand name. When the *European Magazine* received a "new volume of poetry, bearing the noble name of Byron as its passport to celebrity" it knew that the noble name guaranteed certain marketable qualities and connotations. Byron cut a figure as an adventurer, lover and aristocrat gifted with roguish charm. His publisher, his reviewers and his engraved portraits all supported that persona and sold tens of thousands of books. As a result, all eyes were on Byron.

Celebrity culture overcame the feeling of alienation by creating a sense of intimacy. The trick was not to let the poems seem like industrial productions competing for attention in a crowded market. Instead, Byron fostered the impression that his poems could only be understood fully by referring to their author's personality, and that reading them was entering a kind of intimate relationship with him. "They are not felt … as declarations published to the world," wrote one reviewer, "but almost as secrets whispered to chosen ears."

It's been hard for us to see the history of these celebrity strategies because, to a large extent, we live in a culture that's still shaped by them. But celebrity culture looks increasingly worrying, as it colonises politics, business, and even academia. We won't understand what fascinates and troubles us about celebrity culture until we understand that it has a history even longer that Zsa Zsa Gabor's. Uncovering that history has taken me from Byron to Buffy and beyond. It adds to our understanding of the past, but it can also enable us to engage more critically with the present. ■

While Zsa Zsa's certainly not getting any younger, celebrity culture is even older than her. Two hundred years older, in fact.

Celebrity culture overcame the feeling of alienation by creating a sense of intimacy

Tom's £100 prize money will contribute to the cost of including illustrations when this work is published as a book. This work was supported by the Leverhulme Trust.

Enterprise Winner
Judith Evans, Research Fellow in the Food Refrigeration and Process Engineering Research Centre

Futuristic fridges

"How am I going to keep the champagne chilled, the dessert frozen and the cheese at just the right temperature with only the one fridge?"

It is often a chance remark or fleeting thought that triggers the best ideas. Early in 2000 whilst chatting to friends in his local pub Ian Wood heard the landlord agonising about how he was going to cater for a wedding party that weekend. "How am I going to keep the champagne chilled, the dessert frozen and the cheese at just the right temperature with only the one fridge?", he was worrying. It was only later, when Ian thought about what had been said, that he began to consider the problem: was there really no way that someone could maintain several foods at their ideal conditions within one fridge? Further research indicated that this was true; no one currently produced such a fridge. It also became clear to Ian that most refrigerators had an inherent design flaw: when the door was opened all the cold air fell out and was replaced by warm ambient air.

By combining these ideas Ian came up with the concept of 'VariCool', a refrigerator that would store food within four separate, independently controlled drawers that when opened would keep the cold air inside. Each drawer could operate at a different temperature, allowing users flexibility between chilled, frozen or ambient storage. The drawers would also be fully insulated to prevent airborne contamination of odours or bacteria, and a data-logging system would record temperatures for comprehensive due diligence and food safety records. Further ideas quickly followed. Not only would each drawer have its own micro-climate, it could also be removed and used as an insulated box, enabling food to be maintained at the correct temperature during storage or transport. After initial discussions with local caterers Ian was sure his idea was a winner. Further-more, he could see other markets for the unit in the storage of biomedical, domestic and supermarket goods.

Ian Wood was MD of Allied Design and Engineering, a small offshore gas consultancy in Lowestoft. With work in the offshore gas industry reducing, the company needed a new focus. Reborn as Adande Refrigeration and funded by the directors and a bank loan, the process of developing VariCool began. Realising that technical guidance was essential to develop the equipment, Ian sought professional help and quickly teamed up with Judith Evans, a refrigeration expert in the Food →

→ Refrigeration and Process Engineering Research Centre, within the Faculty of Engineering at Bristol University.

Early discussions and consultancy advice confirmed that VariCool was a viable idea, but rapidly identified that this was not a short-term project and that several years' development would be required to produce a commercial piece of equipment. Judith suggested applying for a Teaching Company Scheme (now called Knowledge Transfer Partnership), a government-backed scheme whereby companies can obtain help from research providers, and partial funding would be given to employ a recent graduate for up to two years.

Within six months the funding was approved and a graduate employed at Adande. Work began immediately to develop the first VariCool unit, with staff from the University travelling to Adande on a regular basis to help and advise on developments. The Mark I unit was based on a conventional refrigeration system as, at this stage, the main development work was focused on the design of the drawers and control of the system. During the scheme three Mark I units were built, installed in catering premises and tested to determine how well they operated in a busy commercial kitchen. Since the end of the scheme the Mark I unit has been further developed and is now being produced and sold by Adande.

Design of the Mark II is currently being patented. Based around a novel refrigeration system using capillary tube expansion and a low-pressure receiver, this unit has also undergone extensive testing and development and is about to be produced commercially. This unit has advantages over the Mark I in terms of reduced production costs, ease of manufacture and improved performance. Since the end of the scheme in November 2003 Adande has developed further models while still maintaining links with Judith Evans and her group for ongoing advice and independent testing. The new VariCool units include models with a variable number of drawers, slim-line units and units with varied drawer sizes suitable for differing product requirements.

> It is expected that Adande will have a turnover of around £10m by 2006

Adande has grown very rapidly over the past year, expanding from five to 15 employees as production and sales have commenced. The graduate employed on the government scheme became an essential member of the development team and has since been recruited by Adande. Development of the product and the identification of potential markets directly contributed to the company securing substantial second round Venture Capital funding. It is expected that Adande will have a turnover of around £10 million by 2006.

This is a project that began with a chance encounter that developed through the determination, enterprise and dedication of Adande and the team at the University's Food Refrigeration and Process Engineering Research Centre. Together they turned VariCool into a successful commercial product. Subsequently VariCool has been awarded the European Award for Distinguished Development Design 2003, and the government scheme managers identified as it as one of the top schemes from 2004. ■

Judith won a state-of-the-art Toshiba PDA with wifi, generously donated by Hewlett Packard.

Runner-up
Dr Jeremy Burn,
Visiting Fellow in the Department of Anatomy

Being a good listener

can help racehorses with their problems

When performing strenuous exercise, such as going for a run, the body responds in a number of ways. Most noticeably, the heart beats faster and breathing becomes more pronounced. This is all to do with getting more oxygen into the body to produce the energy needed for exercise; breathing deeply delivers more oxygen into the lungs, and an increased heart rate allows the blood to carry oxygen from the lungs to the muscles more quickly. Animals such as horses need large amounts of oxygen to run fast and have adaptations that make them very efficient at getting oxygen into the body. They have a large diameter airway and nostrils that dilate during exercise to offer low resistance to air entering the and leaving the nose.

Sometimes, however, the airway can become partially obstructed, reducing the flow of oxygen and consequently reducing exercise performance. In humans, it is partial obstruction of the arway that causes snoring, but as we tend not to be exercising when we snore the limitation it would impose on our exercise performance is not of concern. In racehorses, however, the airway can become partially

obstructed during a race, and this can cause an immediate and serious loss of performance. The University of Bristol Equine Centre is one of a small number of centres within the UK that specialises in the diagnosis and treatment of equine respiratory conditions. Diagnosis is made on the basis of visual identification of obstructions as they occur during exercise. Horses are galloped on a high-speed horse-sized treadmill, whilst the airway is observed using an endoscope passed up the nose.

A few years ago we noticed that the diagnoses were being anticipated by our technicians, who hold the horses and encourage them to run on the treadmill. From their position close to the horse's head the technicians were able to hear the breathing sounds produced by the horses and had associated certain sounds with specific diagnoses. Superficially, these observations can be explained using basic mechanical principles: anatomically, airway obstructions are soft-tissue structures that would readily vibrate in an airflow similar to a flag flapping in the wind. Some of these tissues, such as those in the larynx, are quite rigid, whereas those in the soft palate are more flexible. This difference in rigidity causes structures to vibrate at different rates and hence generate different sounds.

We decided that if we could quantify the sound of horses breathing, we might be able to characterise the sounds produced by different types of obstruction. Accordingly, we built a recording system that used a miniature microphone positioned near the end of the horse's nose to obtain breathing sounds. Over a period of approximately one year we listened to horses that were referred to the University Equine Centre with suspected airway obstruction. The human brain is extremely good at processing sounds so there was no guarantee that the skills developed by our technicians could be reproduced using computer software. By extracting the frequencies contained in the sound signal, however, we were able to recognise the sound signature for the most common obstruction of the airway – dorsal displacement of the soft palate.

Although there are still several hurdles to overcome before the sound signatures for all types of equine airway obstruction are recognised, the technique is currently showing promise as a new method of diagnosis. In future, we might be able to obtain a diagnosis by taking the sound measurement system to the racing yard, rather than bringing the horse to the Centre. Consequently, the horse could be tested when on its normal exercise gallop, rather than being trained to run on a treadmill. Collecting enough sound for diagnosis could be completed within an hour and the recording returned to our laboratory for analysis.

Being a good listener to other people's problems involves knowing how to interpret what we hear. Now that we are able to interpret the information that horses are giving us when we listen to them breathing, we can understand better how to address their problems too. ■

This work was supported by Tattersalls Ltd.

Runner-up
Dr Simon Braddy, MSc Tutor,
Department of Earth Sciences

One small step for a bug... a giant leap for life

Fossils are much more than curious objects you find on a beach or in a museum; old bones and ancient shells represent the remains of once-living, breathing animals.

Trace fossils, on the other hand, such as bite-marks and burrows, are the remains of the activities of animals, as opposed to the animals themselves. They are a particularly useful source of information for 'breathing life' into extinct animals, revealing a snapshot in time of their behaviour, providing direct evidence for their locomotion, and even indicating interactions between them. Trace fossils can be found in rocks that were deposited both in the sea and on the land. In fact, other evidence for life on land is rather scarce because dead bodies degrade more easily on land than in the sea.

The fossil record reveals that it was the arthropods – creatures such as spiders, insects and crabs with segmented bodies, jointed limbs, and a hard outer skeleton – who were the earliest animals on land. Even before they left the sea, arthropods were incredibly well adapted for life on land: their exoskeleton, which first evolved in the sea as protection from predators, acted as a spacesuit, shielding them from harmful ultra-violet rays and providing them with mechanical support. The oldest body fossil of a land animal is a 430-million-year-old millipede from Scotland. Body fossils are extremely rare from this time in Earth history, but there is another source of evidence that supplies clues to when ancient life first stepped out of the sea – fossil footprints.

A few years ago there was a ground-breaking discovery in a quarry near Kingston, Ontario in Canada. Fossilised trackways, preserved in a coastal dune deposit, revealed that arthropods first conquered the land around 500 million years ago, some 50 million years earlier than we previously thought. The earliest fossilised footprints prior to that were millipede trails found in Cumbria. Analysis of the Ontario trackways indicates that they were produced by a mysterious group of extinct arthropods called euthycarcinoids. These bizarre-looking bugs resemble a 30-cm-long, flat woodlouse with a tail spine that would have lunged awkwardly across the sand.

They are probably not related to woodlice, however, and recent research suggests that euthycarcinoids were in fact the ancestors of the insects, the most successful and diverse group of animals on land today. The trackways from Ontario indicate that several differently sized euthycarcinoids were on the move at the same time. Who knows, but perhaps they represent the vanguard of an amphibious group exodus from the sea, trekking across the dunes into an unknown land.

Our own ancestors, fish-like amphibians, first lumbered ashore a mere 370 million years ago. There they found a world teeming with plants and giant creepy crawlies. With almost a two-hundred-million-year head start in which to populate the planet before our ancestors arrived, those early arthropods filled an empty niche, evolving into monster millipedes, super-sized scorpions and colossal cockroaches. So, the next time you swat a fly or squish a spider, spare a thought for the true terrestrial pioneers – the arthropods – who left footprints in the sand as testimony to their conquest of the land half a billion years ago. It may have been one small step for a bug, but it was a giant leap for life on Earth.

The oldest body fossil of a land animal is a 430-million-year-old millipede

Simon Braddy's research on ancient arthropods will feature in the forthcoming BBC series *Journey of Life* and *Life in the Undergrowth*. ■

This work was supported by the Leverhulme Trust.

Rob MacNaughton

Arthropod tracks in 500 million-year-old sandstone near Kingston, Ontario

Runner-up
Sue Baic, Lecturer in Nutrition and Public Health,
Exercise and Health Sciences

Do diets work?

Commercial weight loss treatments

"Almost all countries in the world are facing an obesity epidemic"
WHO (2003)

Obesity affects at least 300 million people worldwide. In the UK obesity rates have trebled in the past 20 years to 20 per cent of adults and 10 per cent of children. Projections suggest that unless urgent and effective action is taken, by 2010 almost 30 per cent of UK adults and children will be obese.

> By 2010 almost 30 per cent of UK adults and children will be obese

Well-known complications of obesity include heart disease, high blood pressure, arthritis and type 2 diabetes. However, few people are aware of the increased risk of cancers of the breast, colon and prostate, and even less know about the associations with infertility, delayed recovery from surgery and mental health problems such as depression. Each year the cost to the UK economy is in the region of £2.5 billion from healthcare and work absence. Surprisingly, there is relatively little research on treatment of obesity, and the effectiveness of many commercial diets is unknown. Despite this, in the UK last year 34 million people tried to lose weight, spending £10 billion on commercial diets in the process.

Our study, the first of its kind in the UK, was to to test the efficacy of the most popular commercial weight-loss programmes in obese adults. An additional aspect was that a sample of the participants and the researchers were filmed for *Diet Trials* – a 14-part BBC TV series. Two hundred and ninety three obese adults (27 per cent men and 73 per cent women) were recruited via BBC TV adverts. Over 4,000 people volunteered. The study was carried out in five centres, including Bristol, with roughly equal numbers in each centre. Participants were randomly allocated to one of four diets, or a control group.

For each participant we took a series of measures at the beginning and at monthly intervals over a six-month period. These included weight loss, percentage of fat loss and blood tests, particularly reflecting risk of heart disease and diabetes. Fitness levels were measured using an aerobic adaptation test on a bicycle. In order to develop a better understanding of how to support commercial diets, ten volunteers contributed two interviews during the trial to help inform on their personal experiences.

Two hundred and ten participants completed the six-month study. Although 28 per cent withdrew over the course of the study, there were no differences in drop-out rates between the diet groups. At the end of the trial significant amounts of weight and body fat had been lost in all diet groups, compared with controls – over 300kg were lost in the Bristol group alone. Average weight loss was in the region of ten per cent body weight, 78 per cent of which was body fat. Participants on the Atkins diet lost weight the most rapidly, but this →

‘on trial’!

The diets

Weight Watchers Pure Points

Participants attended weekly group meetings and, using a points system, followed a diet that limited their sugars and saturated fat intake.

Rosemary Conley Health and Fitness

Participants followed a low-fat diet and went to weekly meetings incorporating an exercise class.

Slimfast Meal Replacement Plan

Meal replacements – milk shakes or soups – were used for two meals a day, together with a calorie-counted evening meal.

Atkins Diet

A low-carbohydrate diet was followed where cereals were avoided and fruit and vegetables restricted, but fat and protein were freely allowed.

Control group

Participants were asked to carry on as normal during the initial six months of the trial. On completion they were offered a six-month funded diet of their choice.

➜ levelled off after three months. By six months there was no difference between the diet groups. Fitness levels increased in some members within each group and was associated with an extra three to five kilograms of total weight loss and a greater percentage of fat loss.

Generally blood test profiles showed improvements with weight loss, indicating lower risks of heart disease and diabetes. The Atkins diet had the least effect on lowering blood cholesterol levels. Atkins dieters liked the simple and novel approach at first, but when their diets were examined at two months they revealed worryingly low intakes of fruit and vegetables. As a result we had to commence vitamin supplements and promote potassium intake. The Atkins diet was also significantly more restrictive and expensive than the other diets. Slimfast meal replacements were found to be simple and convenient but participants on the milkshakes reported difficulties with missing solid food and joining in family meals. This made it more suitable for short-term or occasional use.

Both of the ‘group’ approaches – Rosemary Conley and Weight Watchers – were well liked for being easy to follow, and for fitting in with family life. They also allowed plenty of natural and normal foods and treats and offered support and monitoring of progress. The exercise aspect of the Rosemary Conley Health and Fitness plan was particularly enjoyed.

Commercial weight-loss treatments are effective in producing weight loss in individuals who adhere to them. Weight loss reduces the risk from chronic health problems, reflected in a range of blood tests. Increasing physical activity and fitness levels at the same time can improve both weight and fat loss. Interviews confirmed that these outcomes were achieved when dieters received close, regular and genuine support of experts who knew them. The lack of weight loss in the control group confirms that this attention made a profound contribution to the success of these diets.

> Over 300 kilograms were lost in the Bristol group alone

Different commercial diets seem to suit different people according to their lifestyle, eating patterns and their need for support and monitoring. Offering a range of approaches seems to be most useful in helping to treat obesity. Presenting the results of the study as a TV series was a novel way to deliver an important public health message. Furthermore, TV coverage illustrated the daily battle many dieters face, the advantages of different approaches and the health benefits of weight loss. We were able to reach an audience of four to six million viewers per episode. After the show 25,000 informative support packs were sent out. ■

Runner-up
Dr Paul Dean, Post-doctoral assistant,
Department of Pathology and Microbiology

E. coli: a story of Jekyl

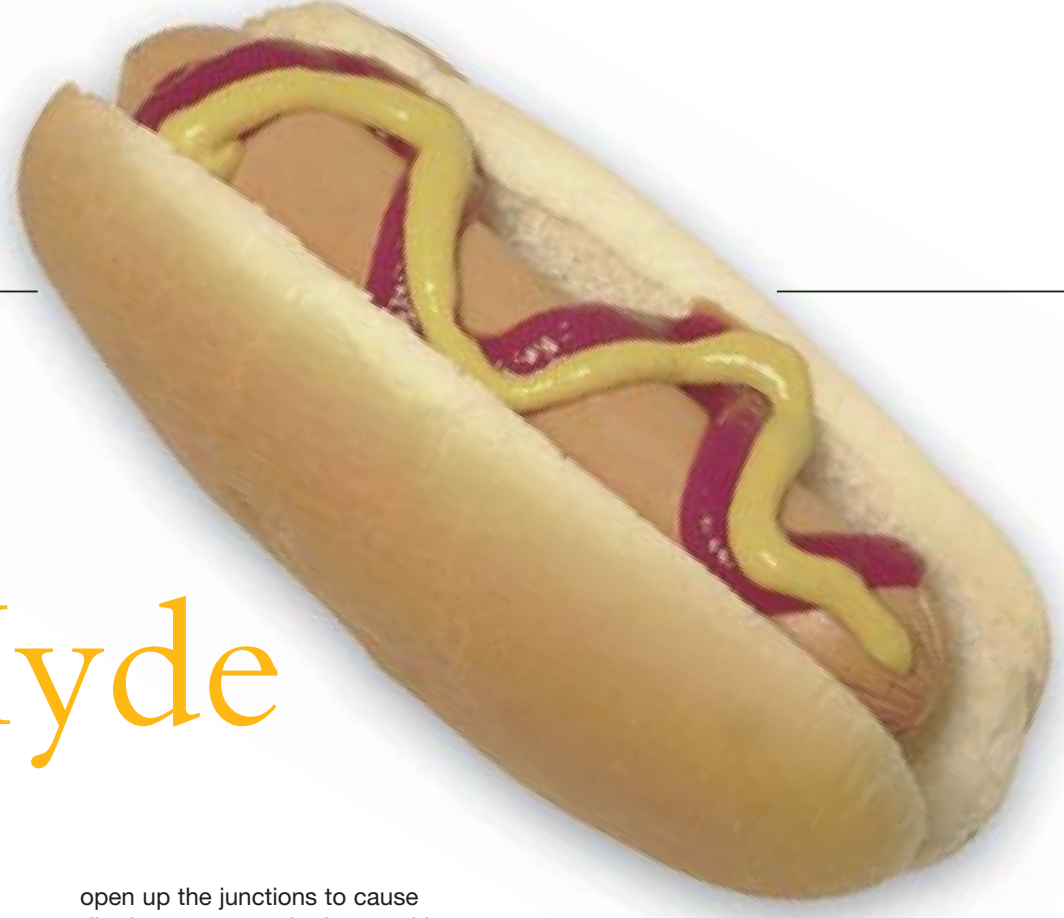
For most non-scientists the term *E. coli* conjures up images of undercooked hamburgers and diarrhoea. However, ask a general biologist and the image of *E. coli* could not be more different.

The *E. coli* bacterium is used in laboratories the world over as an invaluable tool to study all sorts of genes and produce almost any chosen protein. *E. coli* is ideal for this role because its biology is relatively simple, it grows very quickly, it is easy to keep and is nearly always harmless. Despite its infamous public image, *E. coli* is generally a 'good' bacterium found within our digestive tract where it causes no problems at all and may even be beneficial. The problem arises when this amiable little bug picks up bad pieces of DNA from the environment, turning it from a passive, commensal bug into a potentially serious killer. Just a few simple transactions of DNA, combined with a several million years of evolution, and *E. coli* has become a feared infectious agent, capable of killing over a million people each year, particularly young infants or people with compromised immune systems.

So what makes *E. coli* so deadly?

So what makes *E. coli* so deadly? A virulent form of *E. coli* (also known as EPEC) has recently had almost every one of its genes identified by the Sanger Institute in Cambridge, giving us a massive advantage in searching for the genes that cause disease. In Bristol the lab is particularly interested in how *E. coli* is able to cause food poisoning and diarrhoea. Over the past few years research has shown that at some point in its evolution *E. coli* acquired a piece of DNA that gave it the ability to physically 'inject' proteins and toxins into the cells of our digestive tract. It actually possesses a molecular 'syringe' to transfer more than 20 different proteins into the cells of our gut. Once inside the cell, the proteins do a huge variety of things and manipulate the cell for the needs of the bacterium – and in the process our cells get sick and cannot function normally – the result is diarrhoea. What advantage this gives to the bacteria remains unclear. The importance of the piece of acquired DNA can be demonstrated in the lab by putting it into harmless *E. coli*, which then gives it the ability to inject proteins into our cells.

What our work has shown recently is that many of the proteins injected by *E. coli* interfere with the way human cells contact one another. Under normal conditions, cells in the intestine are very tightly joined to each other by closed 'junctions'. These create a barrier to the passage of water and stop it leaking out from the body into the gut. By opening the junctions, the *E. coli* proteins disrupt this cell-made barrier, allowing water to pass through them, which contributes to what we know as diarrhoea. Even more interesting is the fact that the bacteria neatly controls the activity of the injected proteins, only allowing →



and Hyde

→ them to act at set times after injection. This activity is directed by yet another bacterial protein on the surface of *E. coli* that never even enters the intestine cell. So, from its ringside seat on the surface of the intestine cell, *E. coli* appears to be telling its protein what needs to be done – and the outcome is diarrhoea.

There is an astonishing amount of similarity between the injected proteins of *E. coli* and other bacteria that cause disease including Salmonella, Shigella and Yersinia (which was responsible for the plague). So, by understanding how the normally harmless *E. coli* has acquired the ability to cause disease we gain a huge amount of insight into how bacteria in general cause disease and, maybe more importantly, it also provides us with knowledge about how our own cells work. For example, little is known about the mechanisms behind how the cellular 'junctions' are controlled in our intestine, ie what keeps them tight shut. Our work has identified five bacterial proteins that are important in facilitating *E. coli* to open the junctions, allowing a clearer dissection of some of the mechanisms by which these essential junctions work. In terms of therapeutic potential, the advantages are obvious. By understanding how *E. coli* is able to open up the junctions to cause diarrhoea, we may be in a position to close them back up again, possibly halting disease. In addition, all the other *E. coli* proteins that are injected into the cell also have many other functions and the same principle applies to each one. By knowing which proteins are the most important in disease, we now have potential targets for use in immunisation programmes, particularly for vulnerable people in infected areas.

> The potential advantages to be derived from this research are massive

So, from a simple, normally harmless bacterium that exists by the millions in each and every human gut, we are able to learn a huge amount about how bacteria cause disease and also how our own cells function. Until recently only five injected EPEC proteins were known, but this year alone, over 20 injected proteins have now been identified. Clearly, we have only reached the tip of the iceberg in discovering how the injected proteins subvert our own cells, but the potential advantages to be derived from this research are massive. ■

Dr Paul Dean is now at the Institute for Cell and Molecular Biosciences, University of Newcastle upon Tyne. *This work was supported by the Wellcome Trust.*

> By understanding how the normally harmless *E. coli* has acquired the ability to cause disease, we gain a huge amount of insight into how bacteria in general cause disease.

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