University of BRISTOL
2009 CENTENARY
GREAT PAST ~ GREATER FUTURE

re:search

University of Bristol • Research Review • Issue 20 • Spring 2009

aspects of evolution

the financial crisis

digital spying

re: search editorial

Happy anniversary!

This year is a year of anniversaries, the most prominent of which must surely be the birth, in 1809, of Charles Robert Darwin, which was conveniently followed – for those who like anniversaries – exactly 50 years later by the publication of *On the Origin of Species by Means of Natural Selection*, *or the Preservation of Favoured Races in the Struggle for Life*, to give it its full title. Can there be anyone left in Britain who does not know what it was that Darwin gave to science? I hope not. My favourite programme of the many about Darwin was the BBC 4 series entitled *What Darwin Did Not Know*, in which the erudite evolutionary biologist, Professor Armend Marie Leroi, argued that with the new science of evolutionary developmental biology (evo devo), Darwin's theory could be taken to a new level. He considers that it should be possible to predict what might evolve in the future, rather than just explain how evolution occurred in the past.

Not to be left out, *re:*search has also jumped on the Darwin bandwagon and this issue includes three very different articles that are linked by the common thread of evolution. James Marshall explains how mathematical modelling has both confirmed and improved Darwin's ideas on evolution; Samir Okasha explores the philosophical implications of current developments in evolutionary biology; and Mike Benton asks why life is so hugely diverse. All provide fascinating reading.

Other anniversaries this year include the death of George Frideric Handel (1685-1759), 250 years ago, and the death of Isambard Kingdom Brunel (1806-1859), 100 years later. It has been a wonderful opportunity to hear some of the lesser-known works by Handel, but we appear to have exhausted ourselves three years ago celebrating the bicentenary of Brunel's birth, such that the 150th anniversary of his death is passing almost unnoticed. Who is it that decides whether we celebrate someone's birth or death?

In the same year that *The Origin of Species* was published, Alexander Von Humboldt (1769-1859) died quietly in Berlin at the age of 89. It would be a great shame if the life of this great naturalist – once the most famous man in Europe, with the exception of Napoleon – was not being celebrated somewhere. His memorable expedition to South America laid the foundations of the sciences of physical geography and meteorology. Among his many achievements was his development, in 1817, of the concept of isothermal lines, which have enabled us to compare climatic conditions around the globe. On the shoulders of this great giant, we have built our understanding of climate change.

Last, but not at all least, is the University's very own anniversary. In 1909, it acquired its Royal Charter and became the first university to open its doors to both male and female undergraduates on an equal footing. In celebration of this key milestone in its history, the University is organising many projects and activities for staff, students, alumni and the public (www.bristol.ac.uk/centenary). In addition, it has launched the Centenary Campaign to raise funds that will ensure the University enters its second century stronger and more successful than ever before. With a target of £100 million by 2014, its impact will be transformational.

Cherry Lewis
Editor

*re:*search is produced termly by the Public Relations Office, a department of Communications and Marketing Services.

Articles about research at Bristol University are welcome. Please contact the editor.

Editor
Cherry Lewis
Research Communications Manager
Public Relations Office
University of Bristol
Senate House
Tyndall Avenue
Bristol BS8 1TH
email re-search@bristol.ac.uk
tel +44 (0)117 928 8086
bristol.ac.uk

Head of Public Relations Office
Jill Cartwright

Communications and Marketing Director
Barry Taylor

Design, print and production
cw-design.co.uk

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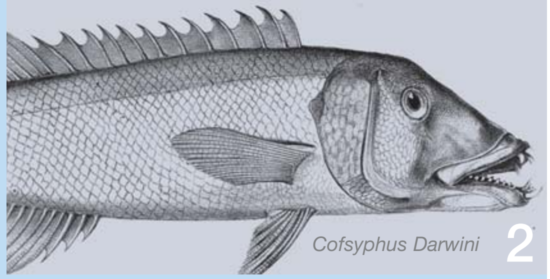
*re:*search No 20, Spring 2009

Printed on Revive 75 silk (75% recycled), using vegetable oil-based inks.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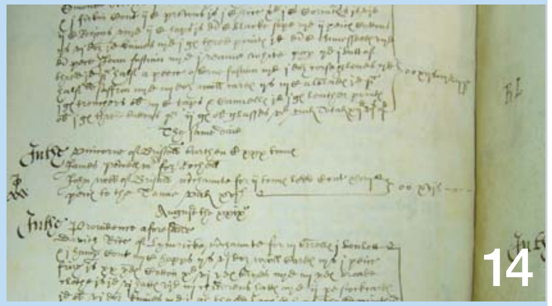
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pre: view

Walking, talking and memory


Dr Dee Way

How easy is it to walk, talk and remember what was said? Dr Dee Way, a keen amateur actor and mature student in Experimental Psychology who, at 62, has just been awarded a PhD, studied how actors learn a script and whether walking affects their memory performance.

Memory for prose is an everyday event; in fact, verbal memory is so much a part of life that it is often taken for granted. The efficiency of verbal memory, however, can vary widely from person to person. Since professional actors specialise in accurate verbatim learning of prose, Way wondered whether they might provide insight into the operation of verbal memory.

Her research first took a detailed record of one professional actor's method for learning a part, much of which was found to relate to maintaining a high level of personal relaxation, working in a calm, quiet environment, making use of personal links to help recall of any unusual items mentioned, and replacing key words with nonsense ideas to emphasise the correct wording. He also undertook intense sessions of examining the language of the text, such as asking why each word was used, why the language was phrased as it was, what the relationships between the play's characters were, and the mood, character and temperament of the role being studied.

Another technique was his extensive use of movement during learning, particularly the use of walking which he employed to characterise the mood of the text and the speed of thought. A series of experiments was therefore devised to test the effect of walking on verbal memory.

In this experiment Way tested professional actors at the London Actor Centre, as well as amateur actors, university students and trainee actors in Bristol, to see if there was any difference in their learning abilities. These experiments showed that for the professional actors, memory performance was the same whether they were walking or were seated. Furthermore, their memory performance was no better than trainee actors or male students. Interestingly, however, she found that female students with no acting experience found it significantly harder to remember material while walking.

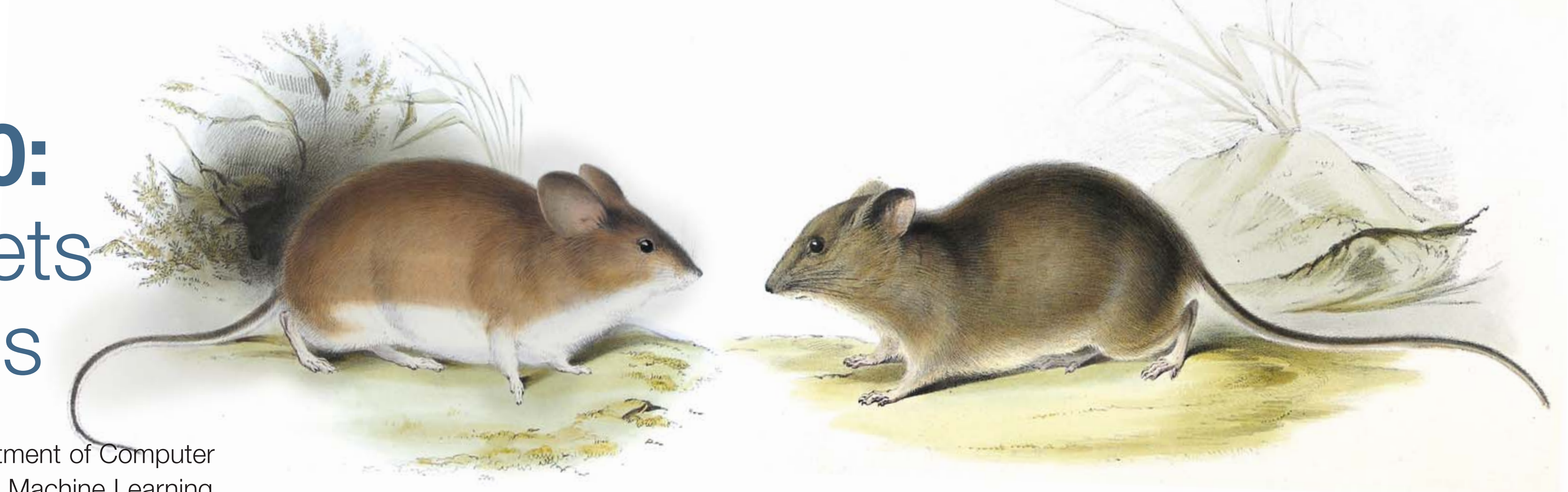
This unexpected result could be accounted for by the fact that there are physical differences in the nerve pathways within male and female brains. Recent evidence suggests that mental processing is more widespread within the brain in females and restricted to more distinct areas in males. Thus, combining activity with memory is more likely to be two distinct processes in men, but to overlap in women. The professional women actors, however, learnt prose just as easily as their male counterparts, suggesting that experience may be an important factor in their learning ability, although further research is needed to confirm this. ■

http://psychology.psy.bris.ac.uk

James Marshall.

Darwin 200: Biology meets Mathematics

James Marshall lectures in the Department of Computer Science where he is a member of the Machine Learning and Biological Computation Group. His research interests include animal behaviour and its evolution. Here he explains how mathematical modelling has both confirmed and improved Darwin's ideas on evolution.



Mus Darwinii (left) and Mus Galapagoensis (right) illustrate the evolution of two different species of mice. Both illustrations taken from *The Zoology of The Voyage of H. M. S. Beagle*. Courtesy University of Bristol Library Special Collections.

Darwin's revolutionary idea that natural selection acting on heritable variation was sufficient to explain both the adaptation of organisms to their environment and the formation of new species, turned on its head the accepted view that species had remained unchanged since the dawn of Creation. However, his naturalist's instincts to collect data supporting his thesis, no doubt combined with a certain wariness concerning the social repercussions of his ideas, led him to leave his theory unpublished for 15 years until, in 1858, a manuscript arrived from Alfred Russell Wallace entitled *On the Tendency of Varieties to Depart Indefinitely from the Original Type*. Wallace had independently arrived at the same theory of evolution by natural selection as Darwin and so, in order to maintain his priority, Darwin rushed to publish a 490-page 'abstract' of his theory in his book *On the Origin of Species by Means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life*. In what Darwin described as 'one long argument', he both presented his theory and reviewed the extensive evidence he had amassed in its support.

Biology and evolutionary theory have moved on a long way since Darwin's time, both in the depth of our under-standing and in the techniques available to us. Darwin formulated his theory without knowledge of how traits are inherited – he assumed that inheritance occurred by a blending of parents' characteristics, despite Gregor Mendel publishing evidence for the discrete, genetic nature of inheritance only six years after publication of *The Origin of Species*. When Mendel's results were rediscovered and interpreted by the scientific community, it took mathematical modellers such as Ronald Fisher, Sewall Wright and J. B. S. Haldane, working in the first half of the 20th century, to reconcile genetics and evolutionary theory in what is now known as the 'synthetic view of evolution', or 'modern synthesis'. Darwin himself was no mathematician, arriving at his startling conclusions solely through observation of the natural world and verbal reasoning. However, his ideas find natural expression as mathematical models of how gene frequencies change in populations over time, and Darwin's theory was vindicated and strengthened by these earliest modelling efforts.

Darwin was no mathematician, arriving at his startling conclusions solely through observation of the natural world and verbal reasoning

HMS Beagle at Tierra del Fuego (painted by Conrad Martens).

Mathematical models are now used to address the problems that Darwin himself was concerned with

Today, Darwin's ideas remain as current and exciting as they did on first being revealed to the world and many of the mathematical frameworks developed by Fisher, Wright and Haldane are also still in widespread use. What has changed is that many of today's biologists are often much more comfortable than Darwin was with presenting purely theoretical results, so that they or others might subsequently look for confirmatory evidence. For those working in the field of theoretical biology, Darwin's work still represents a treasure trove of ideas to be modelled, investigated and refined. Mathematical models are now used extensively to address the problems that Darwin himself was concerned with.

On the Origin of Species

Darwin's *magnum opus* is, as its name suggests, concerned with the problem of how new species arise. One possibility is that populations of a single species can become geographically isolated from each other and, over time, genetic change due to natural selection and other causes will lead them to diverge, so eventually they can be recognised as distinct. This is precisely the mode of speciation famously illustrated by the various finch species that Darwin collected from the different islands of the Galapagos. But is this the only means by which new species can arise? Or can species also arise in response to natural selection alone, as Darwin originally thought, without the need for isolation? It is hard to address such a question empirically. John Maynard Smith was probably the first to treat this question mathematically, in 1966, and over 40 years later the modelling is still going strong. (The answer is 'yes' under certain circumstances, by the way.)

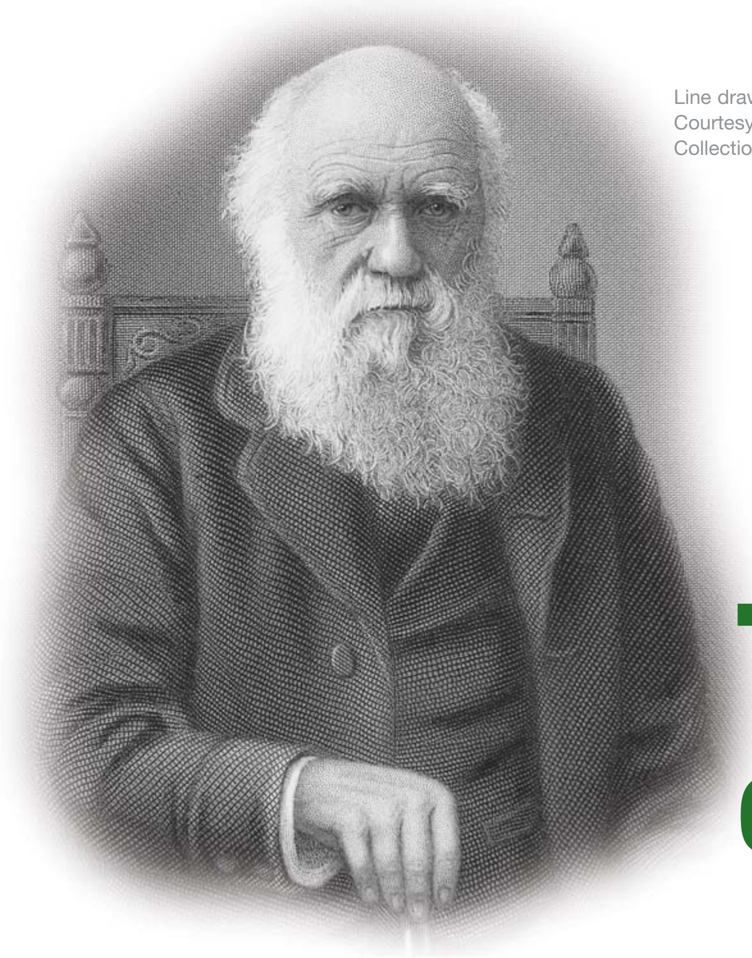
Sexual selection

Any good book should have some sex in it and Darwin's *The Descent of Man, and Selection in Relation to Sex* was no exception. Darwin was interested in how differences between males and females of a species could evolve. The classic example is the peacock's tail; peahens are rather drab, unassuming birds, yet the peacock is resplendent with brightly coloured, very long feathers. Furthermore, these feathers actually interfere with a peacock's flight, so why should it have them? Darwin suspected that the answer to such questions was due to female choice and, indeed, mathematical modelling supports his intuition; males must vie with each other to win over the females and one way of doing this is by having more conspicuous and costly symbols of virility. Thus a peacock's tail and an expensive Saville Row suit have quite a lot in common.

The evolution of co-operative behaviour

The problem of why individuals should co-operate with, or behave altruistically towards, each other has long exercised evolutionary theorists. If natural selection acts on individuals, why should they do anything detrimental to their own fitness in order to help others? Verbal reasoning can let us down badly here and for a long time it was supposed that altruism could spread because it was beneficial to the group as a whole. Darwin himself teetered on the edge of a rare logical error when he wrote, in *The Descent of Man*, that an altruistic primeval man 'might thus do far more good to his tribe than by begetting offspring with a tendency to inherit his own high character'. In 1964 Bill Hamilton showed how altruism could be favoured if the degree of relatedness between donor and recipient exceeds the ratio of the costs and benefits of the act. This formalises Haldane's famous response when asked if he would risk death to save a drowning brother: 'No, but I would to save two brothers, or eight cousins,' he said. Haldane recognised that on average we share one half of our genes with our siblings. Interestingly, it has recently been shown that Hamilton's rule can also be thought of in terms of selection acting on groups – so perhaps Darwin wasn't so far off the mark after all. ■

James Marshall, John McNamara (Mathematics) and Alasdair Houston (Biological Sciences) are organising a 'Darwin 200' conference on 'Mathematical Models in Ecology and Evolution' at the University of Bristol, on 10-11 September 2009. For more information see: www.cs.bris.ac.uk/mmee2009



Line drawing of the elderly Charles Darwin. Courtesy University of Bristol Library Special Collections.

The notion of rationality

Professor Samir Okasha works in the Department of Philosophy, specialising in the philosophy of evolutionary biology. He is particularly interested in interdisciplinary work at the interface of philosophy, evolutionary biology and economics, and has recently been awarded a major grant to study the philosophical implications of current developments in evolutionary biology.

Professor Samir Okasha

Traditionally the philosophy of science tended to mean the philosophy of physics, since within certain areas of physics, particularly space-time physics and quantum physics, interesting philosophical questions arose such that it eventually became a disciplinary branch of investigation. A similar thing has now happened in the philosophy of biology where, over the past 40 years, a conceptual investigation into evolutionary biology has emerged such that the subject is now closer to an exploration of some of the scientific ideas themselves, rather than the traditional philosophy of science.

Okasha's concept of the role of the philosophy of science – clarifying scientific concepts – assumes a fairly sharp distinction between empirical and conceptual questions, but this does not imply that philosophers should be mere passive observers of science. On the contrary, he argues that they can make an invaluable contribution to scientific debates, as long as they are suitably informed. His own field of research is highly interdisciplinary in that he actively collaborates with people from biology, social science and economics, because there are many areas where these disciplines overlap.

Philosophers can make an invaluable contribution to scientific debates

For example, the ways in which co-operation can arise among basically selfish biological organisms have really close analogues in the social sciences and in economics where those very same questions arise about how an individual's self-interest can be reconciled with the good of the whole. To explore these ideas further, he has started a major new collaborative project with Ken Binmore, a well-known economist and game theorist, and one of the founders of the modern economic theory of bargaining.

The overall aim of the project is to study the philosophical implications of recent work in evolutionary biology on the topics of co-operation, social behaviour, and the conflict between individual and group interests. The project will look at the way those topics have been analysed in the social sciences, economics and the biological sciences, and try to look for parallels and interesting points of contrast. It ties in with trying to understand the nature of collective action, and the trade-off between individual self-interest and the common good of society as a whole. Such topics have long been of interest to political philosophers and to social scientists, who have traditionally studied them from the viewpoint of rational choice theory rather than evolutionary theory. Viewed the first way, the issue is whether a rational agent will ever choose to behave co-operatively, or to sacrifice their welfare for that of the group; viewed the second way, the question is whether such behaviours will ever be favoured by natural selection. One major goal of the project, therefore, is to understand the implications of this shift from a rational choice to an evolutionary perspective. In particular, there are striking links between Darwinian theory and rational choice theory, particularly in relation to strategic behaviour, since a notion of optimality is central to both.

There are striking links between Darwinian theory and rational choice theory

The project straddles the philosophy of economics and biology roughly equally and will explore whether evolutionary considerations can help explain behaviour, such as co-operation and altruism, that are hard to account for from a traditional rational choice perspective. Economists have long wondered why it is that people who are supposed to be individually rational and maximisers of self-interest engage in apparently a-rational forms of behaviour by being altruistic, or by exhibiting other forms of irrationalities in their preferences such as heavily discounting the future in favour of the present, or by being strongly averse to risk. Thus altruistic or co-operative behaviour seems at odds with classical rational choice theory of economics.

The second major goal of the project is to explore the implications of recent biological work on 'evolutionary transitions in individuality'. Such transitions occur when a number of free-living biological units, originally capable of surviving and reproducing alone, form themselves into a co-operative whole, generating a new, higher-level individual. This process has happened repeatedly in the history of life, giving rise to the familiar biological hierarchy we see today (gene – chromosome – prokaryotic cell – eukaryotic cell – multi-celled organism – kin group – colony).

Evolutionary transitions raise a crucial question: why was it beneficial for the smaller units to give up their free-living existence and form an aggregate? How did natural selection reconcile the interests of the smaller units with the interests of the whole? Intriguingly, closely analogous issues have arisen in both philosophy and social science.

In particular, the potential conflict between individual and group interests, and the different ways of alleviating the conflict, has long been a central concern of political philosophers, political theorists and economists. Here, one of the key questions is whether the recent biological work on evolutionary transitions can help us understand the nature of human co-operative groups. For example, might the principles which explain the evolution of social insect colonies, in which the individuals work mainly for the good of the colony, also be applicable to human social groups?

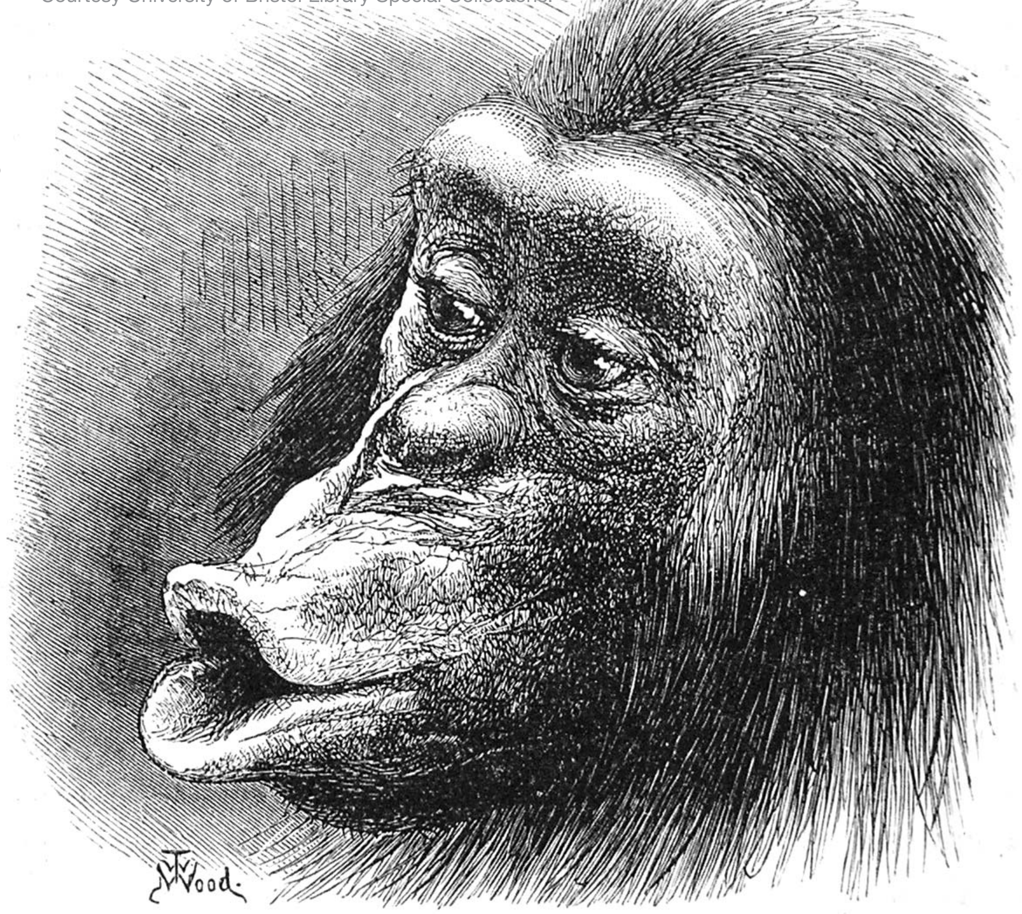
Okasha intends to explore how an evolutionary perspective can help understand behaviours and phenomena

Theoretical work suggests that in order for an evolutionary transition to occur, mechanisms are needed to align the evolutionary interests of individuals with those of their groups. Do such mechanisms shed light on the widely discussed problem in political philosophy of how to reconcile the conflict between individual self-interest and group welfare? Finally, the project will explore whether the theory of evolutionary transitions illuminates traditional metaphysical debates about the 'reality' of human groups and societies. Some biologists argue that a collection of individuals only constitutes a 'real' evolutionary unit, rather than a mere aggregate, if policing mechanisms are in place to regulate the selfish tendencies of the individuals. Others have proposed that real evolutionary units must exhibit 'emergent properties'. What are the broader metaphysical implications of these biological ideas?

Through this project, Okasha intends to explore how an evolutionary perspective can help understand behaviours and phenomena which, from the perspective of rational choice theory, look to be anomalous, and whether ultimately this may lead to new a understanding of the notion of rationality. ■

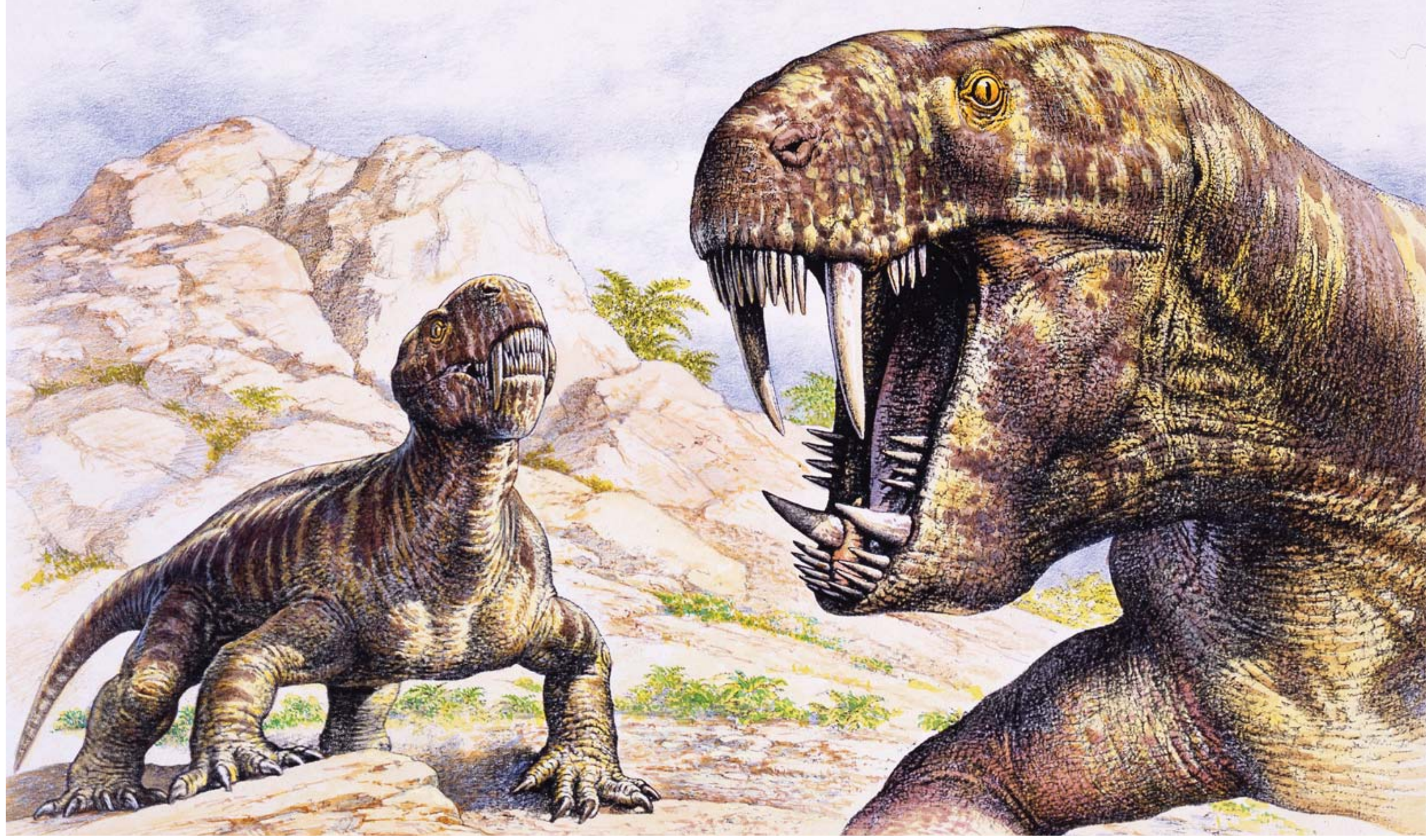
www.bristol.ac.uk/philosophy

'Chimpanzee disappointed and sulky. Drawn from life by Mr. Wood.' An illustration from *The Expressions of the Emotions in Man and Animals* by Charles Darwin (1872). Courtesy University of Bristol Library Special Collections.

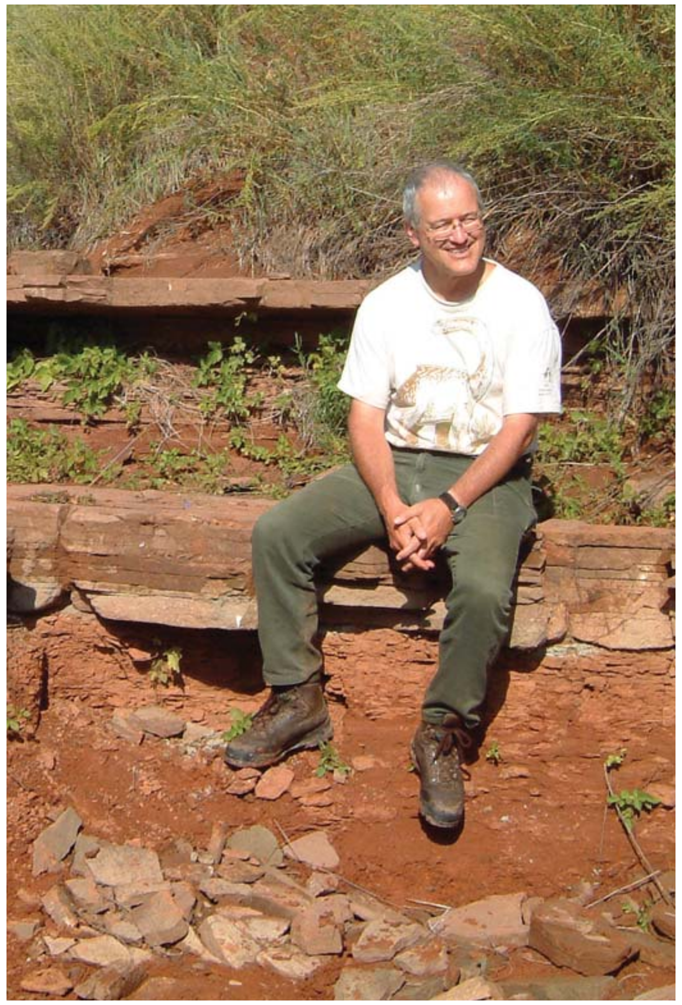


THE RED QUEEN and THE COURT JESTER

A sabre-toothed predator, Gorgonospian, found in latest Permian rocks from Russia. It contained both reptile and mammal features and died out around 250 million years ago. Artwork by John Sibbick.



Life today is hugely diverse and, even before Darwin, scientists – or natural philosophers as they were then called – were debating how such diversity arose. In a special issue of the journal *Science* entitled *Happy Birthday, Mr Darwin*, devoted to species and speciation, Professor Michael Benton in the Department of Earth Sciences was invited to review the history of modern diversity. Here he summarises his thoughts.



Professor Mike Benton sits on the Permian-Triassic boundary in the Korolki ravine, near Sol'Iletsk, southern Russia. This sandstone layer marks a major change in world climates that matched the biggest mass extinction ever, some 252 million years ago, when 95 per cent of all species died out.

The diversity of life – some 10 million species – is a constant source of wonder. Much of our concern today is about the future of this rich biodiversity: what has been the effect of human interventions and population expansions, and how much of today's biodiversity will we leave on the Earth for our children and grandchildren to enjoy? But an even more profound question concerns the origins of modern biodiversity: where did all those species come from, and just why is life so diverse?

The diversification of life can be thought of as an enormous, ever-branching tree, as Darwin pointed out 150 years ago in *The Origin of Species*. Darwin also suggested that all living things are related, so you could follow any lineage back down the tree of life to its origins many millions of years ago. Subsequent work has confirmed this observation and we now know that the first living species appeared some 4,500 million years ago, just a few million years after the planet was formed. But despite this apparent conformity of views among palaeontologists, there are two key questions that remain: first, whether life expanded in a continuous, perhaps exponential manner, and second, whether the main controls on speciation have been biological or physical.

New species are appearing at an ever-increasing rate, and with no sign of an end to the expansion

To take the first of these, the fossil record suggests that, through the past 600 million years at least, the diversity of species has expanded in fits and starts from rather low levels to the present huge figures of many millions. The pattern of expansion seems to have been close to exponential, with new species appearing at an ever-increasing rate, and with no sign of an end to the expansion. This is especially true of life on land where, during the past 100 million years in particular, some groups such as insects and flowering plants have diversified seemingly explosively.

Some palaeontologists, however, argue that these patterns of explosive diversification are artificial, and that much of the 'expansion' depends on the fact that the quality of the fossil record gets poorer as one goes further back in time. Ancient times seem to have low diversities of life because fossils are not so commonly preserved, and the apparent rapid rise in diversity towards the present could be, they argue, merely an artefact of the improving rock record.

These two interpretations require much further work and many palaeontologists are interested in exploring the true, empirical pattern, and the effects of biases. For the present, I argue that more of the pattern is biological than geological, thus life has taken a long time to reach its present diversity, and might well continue to diversify to ever-higher levels.

The other major issue concerns the drivers of diversification. A classic view is that species originate and become extinct largely as a result of interactions with other species; so competition between two species for a limited resource might lead to the disappearance of the weaker competitor. Likewise, the loss of a competitor – on an island, for example – might provide an opportunity for a new species to arise. Overall diversity might then be limited to some equilibrium level, or not, as the case may be, but here the key drivers of diversification are biological (competition and predation). This has sometimes been called the 'Red Queen' view of evolution, after the Red Queen in Lewis Carroll's *Alice through the Looking-Glass*, who said that "it takes all the running you can do, to keep in the same place". In this model, evolution is driven by competitive predator-prey interaction, but the relative ecological positions of the two organisms remain similar as their biotic interactions evolve.

The alternative view, termed the 'Court Jester' model, recalls the capricious behaviour of the licensed fool of medieval times. In this model, evolution, speciation and extinction rarely happen except in response to unpredictable changes in the physical environment. Much recent study of climate and diversity changes through long time spans tends to support this view. External physical factors such as global temperature, sea levels and the relative positions of continents and oceans often correlate well with changes in biodiversity.

So how to resolve these two seemingly quite distinct models of large-scale evolution?

I follow certain previous analysts who have suggested that evolution should be viewed at different levels. This doesn't mean that evolution is necessarily hierarchical in process, but that different processes dominate at different levels of analysis. So, for example, there is no question that the classic Darwinian picture of competition and predation shaping and honing adaptations and species is correct at the ecosystem level and over short time-scales. But at time-scales of millions of years, much larger regional- or global-scale processes overwhelm the scurrying in the undergrowth. A major glaciation or rise in sea level has a large and profound effect; such physical processes may kill species, but in turn that provides opportunities for many new species to arise.

Physical processes may kill species, but that provides opportunities for new species to arise

In conclusion, I would argue that when viewed close up, evolution is all about biotic interactions in ecosystems (Red Queen model), but from further away the large patterns of biodiversity are driven by the physical environment (Court Jester model). ■

www.gly.bris.ac.uk

Professor Nello Cristianini

The privacy delusion

Moore’s Law states that computers double in speed roughly every two years. Alongside this revolution, a new type of society is evolving where the notion of privacy is very different from what we are used to. Furthermore, current laws based on outdated concepts are no longer relevant in this rapidly changing world. Nello Cristianini, Professor of Artificial Intelligence in the Department of Engineering Mathematics, suspects that most of us are blissfully unaware of just how much we are spied upon.

When we play chess online, we don’t expect our intelligence to be measured and compared with our school records, and we certainly don’t expect those records to be sold to recruitment agencies. As we shop for holidays, we do not expect this information to be given to debt collection agencies or credit-scoring organisations. Unfortunately, these expectations may be misleading us, for the world is changing fast.

In order to be useful, information needs to be gathered, stored or transmitted, then processed and finally acted upon. Every step of this chain has undergone major transformations in the past decades and can now be done automatically, cheaply, and very efficiently, by machines. As we conduct our lives in this new and empowering digital age, we leave behind a permanent trail of personal data that is never deleted, never lost. As a result, it is carefully analysed – and even traded – in order that our behaviour can be modelled and, in some cases, influenced. Never before has so much data been collected about so many people with such ease.

We leave behind a permanent trail of personal data that is never deleted, never lost

The AOL case study

Most users of the internet are not aware that it is standard practice for all search engines to gather and analyse a log of every query that each user makes. Together with the content and time of the query, information is collected that allows analysts to identify the machine from which the query has been made using cookies, IP addresses and, in some cases, user login information.

On 4 August 2006, AOL’s research labs released a file on one of its websites containing the search logs of over 650,000 users that had been intended for research purposes. Each user was identified by a unique ID number so that it was possible to connect queries performed by the same person, but not to identify them. A few days later, acknowledging that this was an error, AOL removed the file from public access and those responsible were later fired, but the data are still available at various internet locations, if you know where to look.

This incident gives us a rare glimpse into the often invisible backroom of online businesses, providing direct experience of the trail we leave behind in ‘transaction space’ every day.

User 98280

Let us follow user 98280, probably a couple using the same computer. There seems to be an abusive male and a pregnant female, possibly addicted to cocaine. The query log reveals a series of sessions alternating in topic from *‘ovulation calculator’* to *‘pregnancy calendar’* and *‘effect of addictions on foetus’*, with totally different queries for *‘girls gone wild’* and *‘fine black girls’*. Sadly, we also see queries like *‘dealing with spouse that has bipolar disorder’*, *‘coping with abusive spouse’* and *‘prayers for relationship problems’*. Slowly the story unfolds, revealing the most intimate details and anxieties, and even the intentions, of two people mistakenly under the impression of being in total privacy.

In the AOL query log example, we only have anonymous search queries for a three-month period, but search engines keep data for much longer than that. Often they also have the names and addresses of their users and, if they provide e-shopping services, their bank details. Furthermore, much of this personal information is readily available to various organisations and can be purchased (or rented) like any other commodity.

Much of your personal information is readily available to various organisations and can be purchased (or rented) like any other commodity

Do you want to buy a list of 10,000 alcohol-drinking, pet-owning, frequent flyers from the UK? Names and home addresses? Many companies can help you. One such company will charge a basic rate of £1,700 for a list, more for each additional consumer attribute you want included. The company boasts a database of 40 million individuals living in 22 million households in the UK. Modern pattern analysis by means of intelligent software that uses statistics, artificial intelligence and efficient algorithms can then detect subtle trends and anomalies in these data, again allowing predictions to be made about our future behaviour.

Enter Google

The corporate mission of Google is ‘to organise all the information in the world’. Already it provides (for free) web search, book search and email facilities; as well as online calendar, video, document and photograph storage, and much more. For many of these services you have to give your name and email address and, for the services you pay for, you also need to provide your address and banking information.

Google has also acquired a company, Doubleclick, whose business is to track the behaviour of users over multiple partner websites. Connecting the behaviour of a user when shopping for holidays with the behaviour of the same user when reading the news or searching for a house can multiply the power of the inferences to be drawn about them. Could Google slowly turn into Big Brother, keeping track of its users and deciding what information those users will become aware of? Try sending yourself an email using Google mail, about something you might not want to share with others, and see what appears, within nanoseconds, in the right-hand column of your screen. It’s scary!

My own hunch is that Big Brother … will turn out to be not a greedy power-seeker but a relentless bureaucrat obsessed with efficiency
(Vance Packard, 1966)

Tomorrow’s world?

Today’s technology allows us to collect and exploit a vast number of diverse data about individuals and groups, and we should remember that states, not just businesses, are engaged in gathering information about our activities. We are creating a new type of society where the notion of privacy is very different from what we are used to, and therefore expect. As we sleep-walk irreversibly into this new world, we should develop concepts, laws and values to help us exploit all that information technology has to offer us, without creating a nightmare for our children. We need to be aware that we are venturing into a completely unexplored world – and there will be no going back. ■

To read an in-depth version of this article, visit: www.see-a-pattern.org

Understanding the past to improve the future

Climate change is always in the news these days and it is mostly a message of doom and gloom, but teams around the world, in universities and elsewhere, are doing their best to try to understand what is causing the change, in order to advise governments on how the current rise in global temperatures might be mitigated. A large part of this work involves looking back at the geological past, so we can apply what we learn to the future.

Dr Derek Vance on the Amazon sampling the river.

A new explanation for the cause of changes in the chemical make-up of the oceans through recent Earth history was recently put forward in a paper published in *Nature*. In it, Dr Derek Vance and Gavin Foster from the Earth Sciences Department, with a colleague from the National Oceanography Centre, Southampton, suggest that changes in ocean chemistry through recent geological time are driven by changes in the chemical breakdown of continental rocks through their interaction with rain and ground water. These changes are, in turn, controlled by the profound changes in the Earth's climate that have occurred over the past 2-3 million years.

Changes in ocean chemistry are driven by changes in the chemical breakdown of rocks

The dissolved elements that give seawater its saltiness are mostly supplied by rivers which receive these elements from run-off (rainwater) that has interacted with and dissolved rocks, a process known as chemical weathering.

The other major source of dissolved material in seawater is sub-marine hydrothermal vents that are found along mid-ocean ridges. Movement of seawater through the young, hot oceanic crust that is produced at these ridges causes the leaching out of some elements from sea-floor basalts. But at the same time, some of the constituents of seawater are precipitated out of solution on to the seafloor; thus hydrothermal systems are both a source of dissolved material to the oceans and also a means by which other material is lost. Another major output of material from the oceans goes to form sub-marine sediments, which are primarily made up of the dead remains of the shells of marine organisms. Imbalances in these inputs and outputs cause changes in the chemical make-up of the oceans through time.

Deep-sea sediments also preserve a history of past ocean chemistry and record these changes through time. Vance and his team draw on records of this history to point out that some aspects of the chemistry of the oceans have been changing too slowly over the past 2-3 million years, if what we think we understand about the inputs and outputs to the modern ocean is correct. Specifically, the modern input from rivers to the oceans for some elements is so much bigger than the outputs that the oceanic concentrations of these elements should be increasing dramatically through time – but they are not.

Vance and colleagues go on to challenge the prevailing notion that this inconsistency is caused by inaccuracies in estimates of the impact of hydrothermal systems on ocean chemistry. Instead, they finger potential changes in continental chemical weathering rates – caused by profound climate change operating over the past 2-3 million years – and suggest that chemical weathering rates have been periodically perturbed in recent Earth history by the fact that ice-sheets produced by the great ice ages have physically ground rock up to smaller and smaller grain-sizes. In the succeeding hotter and wetter interglacial periods, this ground-up rock is very susceptible to chemical weathering, since all chemical reactions occur faster if the material on which the reaction is to occur is fine-grained – which is why school chemical experiments use iron filings instead of a block of steel!

One of the authors' main conclusions is that in the instant of geological time represented by, say, the past 100 years, landscapes remain significantly perturbed by this process. The Earth emerged from the last Ice Age only 10,000 years ago and chemical weathering is still playing 'catch-up' with the massive amount of fertile, fine-grained substrate for chemical weathering that the Ice Ages produced. As a result, the measurements of the chemistry of rivers that scientists are currently making are not representative of river chemistry over the past few million years. They only represent now – and now is fairly meaningless in a geological context.

The team concludes by assessing some of the implications of its work. One of these is the potential impact on the natural greenhouse effect on our planet. Chemical weathering not only dissolves rock, it also causes atmospheric CO_2 to react with those rocks, thereby taking CO_2 out of the atmosphere. It eventually ends up in the oceans where it is incorporated into the calcium carbonate shells of marine organisms, which in turn die and accumulate in deep ocean sediment.

No-one should make the mistake of thinking this extracts us from the predicament of high atmospheric CO_2

On long timescales – longer than hundreds of thousands of years – the amount of CO_2 in the atmosphere normally represents a balance between the amount emitted as gas by volcanoes and the amount that gets taken out by chemical weathering. So the conventional view of the long-term evolution of Earth's climate is that chemical weathering and CO_2 act together to thermostatically regulate the Earth's surface temperature. For example, if atmospheric CO_2 increases for some reason, higher temperatures and more rain results in faster chemical weathering, which acts to get rid of the CO_2. Vance and his team suggest, however, that during periods of Earth history when ice is a prominent feature of the surface environment, this thermostat could be over-ridden by the fact that cold temperatures lead to glaciers, which grind rock up. This in turn speeds up chemical weathering, leading to a more rapid removal of CO_2 from the atmosphere. Thus, in periods like the last 2-3 million years, fast chemical weathering rates could act to maintain 'icehouse' conditions once they have started. But, Vance warns, no-one should make the mistake of thinking that any of this can extract us from the modern predicament of high atmospheric CO_2. The natural processes discussed in this article are slow and while they may be crucial on geological timescales, ie, millions of years; they are irrelevant to the short span of human existence. ■

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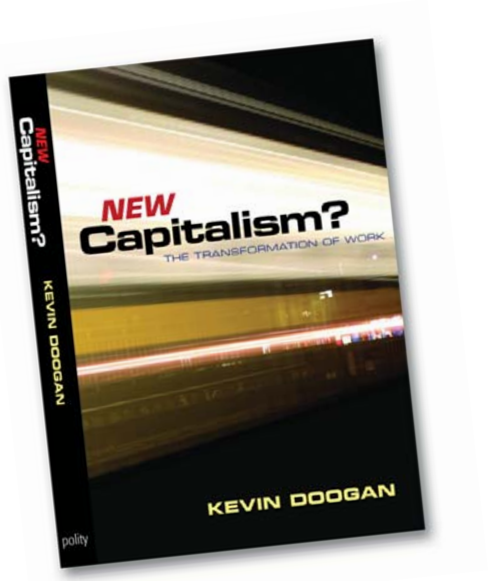
GAVIN FOSTER

Mueller Glacier and pro-glacial lake, New Zealand, with Mount Sefton in the background.

All that glitters: new capitalism and the crash of 2008

Kevin Doogan in the School for Policy Studies sheds some light on why we are in the current financial crisis.



Kevin Doogan's book, *New Capitalism? The Transformation of Work*, was recently published by Polity Press.

In the midst of the current crisis, it is hard to remember that commentators, until recently, waxed lyrical about the wonders of a 'new economy'. Globalisation, technological change, deregulation and market liberalisation were portrayed as immutable forces driving the world economy onwards and upwards. Unfettered markets were said to give rise to a new, dynamic phase of capitalist development as free trade embraced the developing economies such as China and India. Markets had become flexible, trades unions were consigned to history and the gains in employment were there for everyone to see. All boats were lifted on the rising tide of consumer spending as the rising housing markets fuelled asset accumulation and borrowing on an unprecedented scale.

Rising housing markets fuelled asset accumulation and borrowing on an unprecedented scale

Not only will historians look back at the crash of 2008 and recall an extraordinary turnaround in economic fortunes, but the more astute observers will realise that the seeds of downfall were sown in the very symbols of success. Already talk of the new economy has been replaced by talk of the 'bubble economy', the bursting of which has led to repossessions, debt deflation, overproduction and widespread job losses. The first signs of decline may have been evident in the housing market, but the deeper and wider weaknesses in the economy are becoming ever more obvious. Historians will surely recall that the housing market was not the first bubble to burst during the era of new capitalism. In the mid-1990s speculative investment in the dot.com industries came to grief as dot.com became dot.bom.

The bursting of the dot.com bubble presaged several investment bubbles in mobile communications and fibre optics. The rapid expansion of fibre optics in the 1990s was based on the incredible assumption that internet usage would double every 100 days, or some 1,000 per cent per year. As it turned out, the growth rate was only around 40%, a rate completely unable to sustain the frantic investment in telecoms during the second half of the 1990s. In the United States, it has been estimated that some 39 million miles of cable were laid – enough to circle the globe 1,566 times – but only 3% of capacity was being used by the middle of 2001. The resulting telecoms crash led to the loss of three million American jobs in the early years of this decade. It is reasonable to assume that the history of the new economy will link a series of such telecom bubbles – dot.com, fibre optics and 3G – to the surge in lending in the sub-prime housing markets that produced the toxic assets which spread like a virus through the global financial sector. These bubbles were all products of deregulation, they all were global to a greater or lesser extent, and all led to overproduction and debt overhang.

If we are to have any chance of charting our way out of the current crisis, it is necessary to explain the rise of a more irrational form of capitalism. Arguably we have to root these developments in the rise of neoliberalism, the era of capitalist development that can be traced back to the rise of Regan and Thatcher. Neoliberalism has three features that not only help explain the fragility of the bubble economy, but also reveal the nature of wealth accumulation in this period. These include deregulation, financialisation and changes in corporate governance.

In the middle of the last century, the Bretton Woods system of monetary management established the rules for commercial and financial relations among the world's major industrial nations. Its collapse in 1973, with the abandonment of exchange rate controls and the acceptance of floating rates, was the first sign of the new monetary and financial order. Limits on capital movements were lifted in 1974 in the United States and in 1979 in the UK. Subsequent deregulation of telecommunications, airlines and finance also greatly reduced restrictions on corporate freedoms. Finally, corporate taxes were slashed and the top rate of taxation reduced from 70% to 28%.

Financialisation involved the rebalancing of wealth between financial and non-financial corporations, such that the relative net worth of financial to non-financial corporations grew from 12 to 23% in the two decades before 1999. Moreover, production industries began to extend their operations into financial services as mergers diversified activities across sectors, blurring the boundaries between finance and production. It has been suggested that neoliberalism 'has meant the financialisation of everything'.

There were two key changes in corporate governance over the past 25 years. Firstly, a 'second managerial revolution' emerged in the early 1980s that was marked by the rise of a new breed of management gurus. This new managerialism, disdainful of economic planning, virtually celebrated the irrationality of the market, suggesting ways of 'thriving on chaos' during the 'disorganisation of the nanosecond nineties'. Secondly, there have been critical adjustments in the remuneration of executives whose wealth has grown spectacularly during the last 20 years. Executive income, based on bonuses and share options, came to be tied, not to corporate profitability, but to rising share values whose link with economic realities grew increasingly tenuous. Thus the chief executives' share of equity in US corporations grew from 2% in 1992 to 12% by the end of the decade. The result has been described as 'one of the most spectacular acts of appropriation in the history of capitalism'.

These developments must be factored into the radical policy rethink that is currently under way. As the fire-fighters of global capitalism struggle to stem the tide of further economic decline, it is hard to overstate the depth of the policy dilemmas. Government measures are under consideration that would have been unimaginable this time last year. When the former chairman of the US Federal Reserve is referred to as 'Comrade Greenspan' for his support of nationalisation, and when the *Financial Times* runs a headline (23 February) 'In Praise of Rigidity', arguing that the inflexibility in the labour market was a key defence against debt deflation, it becomes clear that the intellectual edifice that has supported the growth models of the past three decades has utterly collapsed. This crisis calls on to the stage those who have challenged the economic orthodoxies that have underpinned neoliberal capitalism. If we are to restore rationality to the management of the economy, nothing short of a full-scale policy reversal will suffice. ■

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Consuming Ireland

In view of the current global economic crisis, partly the result of the hyper-consumption of material goods, research that seeks to understand historical consumption has never been more relevant or timely. Work by Susan Flavin, in the Department of Historical Studies, shows that dramatic changes in consumer consumption can occur in the most unlikely of societies.

Susan Flavin

Limerick, Ireland

Flavin's research examined changes in the nature of Ireland's trade with Bristol in the 16th century. The customs accounts and Port Books of Bristol are an outstandingly detailed record of Anglo-Irish trade, recording as they do in minute detail what was the most important branch of Ireland's overseas trade. The records are particularly invaluable because the public records office in Dublin was destroyed in 1922. No other economic records of equivalent value survive in Ireland, or elsewhere, for examining Ireland's economic development during this period.

Ireland remained dependent on imports for the vast majority of every-day goods

The nature of the Irish economy meant that Ireland remained dependent on imports for the vast majority of every-day goods during this period; the accounts therefore paint a very detailed picture of the evolving nature of Irish material culture and of changing patterns of consumption. Many of the items that appear in the accounts are the kind of low-value consumables that normally do not survive in other sources. However, such detail allows Flavin to look at important social and cultural issues such as changes in the rituals of the table, in hospitality, in the preparation and presentation of food, in defense, fashion and leisure activities – even down to how the inhabitants of 16th century Ireland coped with such annoyances as constipation and intestinal worms.

After 1575, the accounts tell us the exact port at which goods were arriving in Ireland, and also the domicile of the merchants, which is a vitally important detail as it throws light on the probable diffusion of goods after their arrival on the Irish coast and on the commercial relationship of the Irish coast and its hinterland. The analysis conducted so far reveals that there was a dramatic increase in the range and volume of luxury goods imported from Bristol, which rose from just 60 basic items in 1503 to almost 400 by the end of the century. Growth has been identified in two main areas: the increasing diversification of product types – buttons, for example, evolved from a single category to a large range of sub-types – and the appearance of entirely new items, such as soap and spectacles, an increasing variety of luxury European cloth and foods, and a range of items described as being specifically for children. These goods were widely distributed throughout all the main towns in the south-east of Ireland, and also further west to Limerick and Galway and north to Dundalk and Drogheda.

These findings are surprising because it is widely accepted that the 'birth' of a consumer society in Britain did not occur until the 18th century, in line with growing industrialisation and commercialisation.

Ireland in the 16th century, which is still seen by economic historians as a colonial backwater, is a very unlikely place to find significant changes of this nature. One major social upheaval that might explain such changes was the creation of the Munster Plantation. Munster was a province of Ireland where land seized from the Irish was given to colonists ('planters') from Britain. These 3,000 'New English' settlers were an attempt by the Crown to both stabilise and anglicise the country. This, however, did not begin until 1586/87 and the accounts suggest that major changes were under way well before then, making it necessary to consider organic reasons rather than colonisation for these apparent changes.

While one might expect the growing range of luxury items to reflect increasing wealth in Irish society, the overall value of the Bristol-Ireland trade seems to have collapsed at the same time as luxury imports increased. The 1575 account shows the greatest increase in terms of the range of goods being imported, but also the lowest recorded gross value for trade. It seems that while the variety and, in some cases, the volume of small luxury items was going up, there was a corresponding fall in staple goods such as broad cloth, saffron and raw silk, which together made up the largest part of the gross value of import trade in the first half of the century.

In order to understand this dichotomy, Flavin has examined Ireland's exports, in addition to its imports (the accounts record both). Found among these in the later part of the century are commodities such as marmalade and wine which make up almost a quarter of the value of Irish exports in 1594. Indeed, in that year Irish merchants exported four times more Spanish hat wool to England than they did Irish wool, and by 1600, Seville oil made up 11 per cent of Irish exports to Bristol. This suggests well-developed Irish mercantile contacts with Spain – a commercial relationship that is backed up by qualitative evidence in the State Papers. It seems that Irish merchants were being increasingly drawn towards European markets, which helps explain the decreasing value of Ireland's trade with England.

While Irish consumers remained for the most part dependent on imports for everyday manufactured goods, it is

Teazles are used to draw out the ends of wool to make a fine, high-quality cloth

apparent that some of their growing needs were being met by domestic production. Evidence of this is seen in the importation of teazles – plants used to draw out the ends of wool to make a fine, high-quality cloth – which began to occur around the same time as the increase in luxury cloth imports. The Irish also imported an increasingly diverse range of haberdashery items, including specialist needles and threads, along with items such as shoe-makers' knives.

Flavin is not suggesting that 16th century Ireland showed all or even many of the features of a modern consumer society, or that it underwent a 'consumer revolution' of the type claimed by historians of 18th century Britain. Nevertheless, analysis of the Bristol customs data points to a dramatic shift in the nature of Irish consumption by the last quarter of the 16th century, indicating both a growing sophistication of tastes and an increasing prosperity in Ireland.

While statistical data are at the core of this study, Flavin's remaining work will focus on using qualitative sources such as wills, inventories and state papers to explain how these commodities were interpreted and perceived, and what they tell us about identity in Ireland. Such records can throw light on the cultural identities of the consumers of these goods, the changing role of women and children as consumers, and the ways in which Irish material culture was affected by colonisation in the final decades of the century. ■

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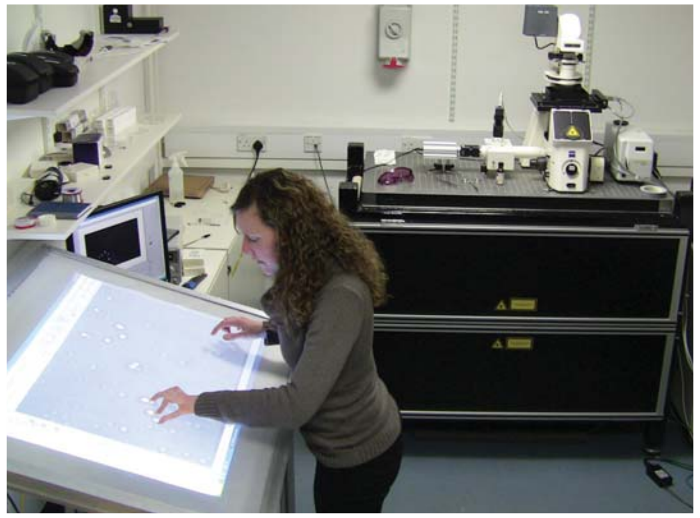
Dr David Carberry

The dream of nanoscientists is to assemble nanoscale structures that can be used to do things like manipulate living cells or fabricate 3D electronic and photonic structures. The problem is, how do you control particles that are so tiny you cannot even see them under a microscope? Dr David Carberry in the Department of Physics does it with light.

NANOSCIENCE AT YOUR FINGERTIPS

When light is focused in a certain way, it can be used to 'trap' a small object and is stable enough to hold a droplet of water hovering in mid-air as if it were being levitated. In a similar way, Carberry uses the light from focused laser beams to hold particles, such as blood cells or pieces of DNA, in a fluid. Once trapped he can then manoeuvre the particles to wherever he wants them to be. But, given their tiny size, just how does he do this?

Optical tweezers are systems that use laser beams to 'trap' and manipulate very small particles. They have been around for some years and are used to investigate numerous areas within physics, chemistry and biology, but they are highly optimised for specific tasks and seldom allow the control of more than one trap at a time, thus proving to be rather limited in their function. Around 2002 a new technology emerged – a computer-controlled hologram – which suddenly allowed scientists to control more than one focused laser beam at a time, and therefore move more particles.



The multi-touch table being used to move particles that are located under the microscope on top of the Dynamic Holographic Assembler, the black machine in the background.

A hundred laser beams can be precisely focused and individually manipulated in full 3D

But, like much of today's technology, within a short time even this improved facility was not sufficient for Carberry and his colleagues in the bio- and nanoscience groups who wanted to use such holograms to control dozens of particles at a time. So, in collaboration with colleagues in Glasgow, they built the Dynamic Holographic Assembler (DHA). This state-of-the-art machine now allows users to simply click on a screen and use the mouse to position a laser beam exactly where it is needed in order to 'trap' the required particle, which can then be moved into position. Furthermore, a hundred beams can be focused in this manner, and they can each be manipulated individually in full 3D. But despite this improvement, the team considered the system was still not 'friendly' enough for non-specialist use, so its next goal was to design a very intuitive interface that even a child could use.

In collaboration with the University's Department of Computer Science, a multi-touch table was developed that would allow each of these optical traps to be controlled by using one's fingers. The multi-touch table looks very much like a large PC monitor lying face up on a table. On it a few dozen round particles, roughly the size of a marble, are randomly displayed. These particles are actually beads of silica about two microns in diameter – three times smaller than a red blood cell – that are lying under the microscope positioned on top of the DHA. They have been greatly magnified and projected on to the multi-touch screen. To demonstrate how they can be moved, Carberry places three of his fingers on the images of three silica beads and, pressing very gently, he drags them across the screen, lining them up in a neat row. Further beads are captured to form new rows and then another layer is built on top of the first one. Gradually it becomes apparent that he is forming a 3D structure which, in reality, is being built under the microscope across the other side of the room.

Ultimately, what Carberry wants to be able to do is assemble a much larger 3D structure called a photonic band gap crystal. Photonic crystals are structures with deliberate defects and impurities, and with properties that prevent the propagation of certain frequencies of light, while permitting others. Such properties will enable Carberry to control light with amazing facility and produce effects that are impossible with conventional optics. In the same way that transistors enabled all the micro-electronics of today, photonic crystals will act as a 'switch' for photons (light) and enable tomorrow's optical computers. The DHA could therefore become one of the manufacturing processes of the future, turning out photonic crystals instead of microchips.

He then shows how, using the two beads as handles, he can move the tool around. Being able to do this efficiently will enable the micro-manipulation of things such as brain cells or DNA in order to understand better how they respond to the forces applied to them when, for example, the need to insert or attach a drug arises. Using this nanotool, Carberry can 'feel' the force being applied and know how hard to push in order to position a drug very precisely. Alternatively, he may want to determine whether the cell being examined is cancerous. A cancerous cell has very different properties from a healthy cell and, by poking it, more information about its surface properties could be obtained, aiding those engaged in the fight against cancer. These tools may also be capable of modifying cells using a kind of nanosurgery. Collaborations are already under way with biomedical groups working on cardiac stem cells and neurons.

The dynamic holographic assembler could become one of the manufacturing processes of the future, turning out photonic crystals instead of microchips

But that's only one aspect of what the group is doing. Another is building nanotools, which in turn will enable the team to build nanostructures to build even smaller nanotools, with which to build even smaller nanostructures until eventually individual atoms can be controlled. Carberry demonstrates one part of this process by attaching two beads together using a tiny nanorod.

The team has recently won a grant of over a million pounds to push forward this new and exciting technology of the future – a future that, it seems, is not only very bright, but also very small. ■

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Public Relations Office
Communications and Marketing Services
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