A worthwhile investment: research-council scientists speak out

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This article looks at the work of two of the UK's research councils and the way their funding contributes to science at large, and to the scientists themselves. Nina Morgan talks to three scientists from the Particle Physics and Astronomy Research Council and three from the Natural Environment Research Council about their interests and enthusiasms.

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1. Introduction

Many of the scientists contributing papers to these special triennial issues of the Philosophical Transactions will have one of the UK research councils to thank for getting them where they are. In this first issue, devoted to Astronomy and Earth Science, the relevant councils are the Particle Physics and Astronomy Research Council (PPARC) and the Natural Environment Research Council (NERC). Even if the research they present has not directly been supported by one of these bodies, it is a fair bet that the scientists themselves have benefited from research-council support at some time during their careers, in the form of either postgraduate studentships or postdoctoral research posts.

The PPARC science programme spans the study of the infinitesimally small to the unimaginably large: from hypothetical superstrings, just $10^{-35}$ m long, to giant clusters of galaxies, tens of millions of light years across. On the way it takes in such fundamental questions as the origin of mass, the reason for the existence of precisely three generations of elementary particles, the cause of the matter–antimatter asymmetry in the Universe and the nature and amount of ‘dark’ matter. It seeks to understand the origin and evolution of the Universe and to discern the physical processes in, and the origins of, all the structures it contains: planets, stars, the interstellar medium, black holes, quasars, galaxies, clusters of galaxies, etc. And closer to home, the programme aims to increase our knowledge of the way the Sun works and how it interacts with the Earth. For further information, the interested reader might like to visit the PPARC Web site at http://www.pparc.ac.uk/.

One contribution of 20 to a Triennial Issue ‘Astronomy and Earth science’.
Meanwhile, the NERC’s mission is to promote basic, strategic and applied research and to support long-term environmental monitoring and related postgraduate training. Its fields of interest include marine and freshwater biology and the Earth’s environment, the latter embracing the atmospheric, hydrological, oceanographic and polar sciences. In this way it advances knowledge and technology and provides services and trained scientists to a wide range of users and beneficiaries. These include the agricultural, construction, fishing, forestry, hydrocarbons, minerals, processing, remote-sensing and water industries. The NERC thus contributes directly to the economic competitiveness of the United Kingdom, the effectiveness of public services and policy and the quality of life. More information is given on the NERC Web site (see http://www.nerc.ac.uk/).

2. The scientific career

Devoting oneself to scientific research can be challenging, stimulating and intellectually rewarding, but today it is not always an easy career option. Aside from tackling the scientific problems, researchers everywhere face the dilemma of how to pay for it all. Ultimately, all the research funded by the UK research councils is paid for by taxpayers and, like all bodies funded from the public purse, the research councils must constantly account for and justify their spending. Worthy though their missions are, it can be difficult to ‘sell’ the value of curiosity-driven basic research both to government paymasters and to the public at large. As a result, the threat of funding cuts for basic research often looms large. For the researchers themselves, the threat of budget cuts means increased competition for funding and, although most scientists would agree that money is not the main motivation for their research, they are nevertheless people too. Like everyone else, they have families to support and mortgages to pay.

So, given the uncertainty of research funding, a career path that is far from guaranteed and a salary scale typically below what they could hope to earn in industry, why would anyone choose to pursue an academic career in scientific research? To try to answer this, the PPARC and the NERC have funded science writer Nina Morgan to speak to six young scientists whose work they support, to find out what excites them and motivates them to carry on with their research.

3. Interviews with the scientists

(a) Jon Butterworth: curiosity driven

Jon Butterworth (figure 1) gained plenty of experience working on big experiments, both while working for his DPhil in physics at the University of Oxford, and during a postdoctoral position at Penn State University in the USA, when he worked on the ZEUS experiment on the HERA collider ring near Hamburg. He is now 34, a lecturer in particle physics based in the Department of Physics and Astronomy at University College London (UCL), and still into big science. He is currently involved in the Geneva-based ATLAS experiment, one of the big experiments driving the e-science initiative.

I got interested in particle physics partly because I read too much science fiction when I was young, and partly thanks to a maths teacher I had

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when I was about 16. He showed me the way that maths, which appears like such a human and abstract activity, seems to map on so readily to the Universe around us.

I love the beauty of the theories in particle physics because they try to go as fundamental as possible. In a way, the complex experiments are all designed to try to make the conditions as simple as possible so you can see the underlying theories. I work closely with theorists, but I’m really an experimentalist. Although I find the theories beautiful in themselves, to me the real fascination is that they bear some relation to what is going on in the world. I look at nature and I wonder why on Earth it should behave according to these simple beautiful theories. If the theories were just constructs on their own, I don’t think they would be so interesting. And experimentalists use a lot of cool technology, which I do enjoy.

Particle physics research is really curiosity driven. It’s human beings trying to find out where they live as accurately as they can, trying to study the extremes of the Universe around us. Still, when you learn something new, uses for it often follow. It would be wrong to pretend that we are in the business to produce applications—our research is not commercially driven. But although there is no direct payback in a business sense, there is a huge payback in terms of physics students coming through the system and technological spin-offs. The [World Wide] Web, for example, was invented at CERN. And particle physics is a big driver for the e-science initiatives. Although you wouldn’t fund particle physics if the aim was to develop distributed computing, if you fund particle physics, you might just get distributed computing anyway.

I think it’s vital that the governments continue to fund this type of research. If you took PPARC’s funding for curiosity-driven science out of universities, you would lose such a lot of well-motivated students through
the system, and essentially close down a few physics departments in major universities. We would also be closing ourselves off from one of the most exciting frontiers of human knowledge. As I see it, from the Government’s point of view, funding this type of basic research is like casting bread upon the waters. It’s not much bread, but the potential payback is great.

(b) Ian Wright: out of this world

After finishing a first degree in geological sciences, Ian Wright (figure 2a) went to the University of Cambridge to do a PhD studying lunar rocks. But as it turned out, it was the instrument-development side that really caught his imagination. One thing soon led to another.

We quite rapidly arrived at the point where we had tremendous instruments—like mass-spectrometry systems to analyse very small amounts of carbon and nitrogen—and that’s when I really got interested in meteorites. I’ve been working on them ever since. Working on meteorites tells you things about the cosmochemistry of the Solar System that you cannot get by studying Earth rocks. We’re concentrating, for example, on two big questions. How did the Solar System form and why? And what is the origin of life? The beauty of studying meteorites, which ultimately come from asteroids, is that you are studying the fossils of processes that happened 4.5 billion years ago. And that’s just incredible because there are no rocks of that age on Earth.

We also have a big grant from PPARC to build an instrument that will fly on the Rosetta spacecraft (figure 2b), due to be launched in January 2003. The mission aim is to land on a comet. Our instrument will analyse the volatile constituents of the cometary ice and dirt, like water and carbon dioxide, and measure stable carbon and oxygen isotope ratios. Aside from the science, it’s a very exciting project because we’re the only UK institution that is playing a principal investigator role on Rosetta: a real boost for the UK’s profile in space research.

Continued government funding is essential for our research. Fortunately, we’re actually blessed with a subject that is relatively easy to convey. People are naturally interested in it and generally do understand why funding should continue for this sort of work, much of which involves pure scientific investigation for the sake of it. But there is a side of our work that is potentially of tremendous practical relevance. Very small pieces of interplanetary dust travelling at hypervelocities ranging from 15 to 20 km s\(^{-1}\) have the potential to destroy £100 million satellites, so it’s important to understand how to develop materials that will resist the effects of these impacts. And when we study meteorites, we are effectively at the sharp end, analysing small samples of potentially hazardous near-Earth objects close-up. If one of those is on a collision course with the Earth, determining the best strategy to deal with it might be based on what the thing is actually made of. Just blasting a nuclear warhead at it might not be the best idea!
Research-council scientists speak out

Figure 2. (a) Ian Wright. (b) A view of the instrument known as ‘Ptolemy’, which will be included on the lander part of the Rosetta mission to a comet (due for launch in January 2003). This instrument (a miniaturized gas-chromatograph mass spectrometer) will analyse the nature and stable-isotopic compositions of cometary volatiles. The overall device, including all of the electronic control supplies and computer, weighs 4 kg and runs on a few watts of power (roughly the power needed to light a torch bulb).

(c) Phil Mauskopf: interested in everything

Phil Mauskopf (figure 3) was born in England, but has spent most of his life so far (and obtained all his degrees) in the USA. Nearly two years ago, at the age of 31, he accepted a permanent position in the Department of Physics and Astronomy at Cardiff University. Although some of his US colleagues thought he was crazy to move to the UK, he has no regrets.

It’s been easy to integrate myself into the UK cosmology community. And although the pay may be lower in the UK than in the US, the system,
from the junior to the senior levels, is a lot less stressful. Also, science and academia in the UK seem a little bit more academic than in the US and there is more academic freedom. There are politics everywhere, but in the UK system it is more accepted that part of the reason why people choose to be an academic is because you hope people will leave you alone so you can think up new ideas.

This is great, but I have a problem in that I find too many things interesting! However, there is a common theme. In everything that I really enjoy there is a challenge, and that challenge is to do something that nobody has ever done before. It could be discovering something brand new about the Universe, or inventing a new type of detector, or building a new kind of camera for a telescope. I also enjoy learning new languages. I’m wanting to learn everything about everything, even though I recognize that it’s clearly impossible.

Cosmologists are often asked why the governmental research councils such as PPARC should support their research. One of the stock answers people give is about useful technology spin-offs. While it’s true there is an overlap developing between the technology used for astronomy and that used for things like the mobile Internet, these spin-offs weren’t the intention.

But government support for science is a really good thing on many different levels. One has to do with education. It’s really important to have a society where there are some people who are trying to do cutting-edge work and pursue knowledge—people that others can just learn from and be inspired by. Students find that kind of thing much more inspi-
rational than just reading from a book. There is also a cultural aspect. A lot of the more esoteric work on things like the origin of the Universe clearly doesn’t have any direct technological applications, but it has an equivalent cultural interest to art or music or dance. Scientific ideas can influence socio-political thinking even more than art or music often can. If ideas like relativity and quantum mechanics get into the common mindset, they do influence the way that people think. Space travel might be one of the most significant examples. I think concepts and achievements like this do influence the way that a lot of people think about basic and fundamental concepts like our place as human beings in the Universe.

(d) Carole Llewellyn: a biodiversity of interests

Carole Llewellyn (figure 4), a marine chemist, worked in the pharmaceutical industry before joining the staff at the Plymouth Marine Laboratory in the 1980s. Now 42 years old, and the mother of two boys aged 10 and 12, she does not regret her choice of career. Her NERC-supported research pays her to do something she really enjoys.

I’ve always been interested in our natural world and looking at the biodiversity of the planet. The oceans are part of that system. When I was growing up, I used to love looking at the different animals and plants in rock pools. I had the kind of enquiring mind that made me always want to do experiments. This kind of job fulfils that in me. And I’ve landed in a really interesting area of science.

My work is divided into two areas: what might be called pure science and also something a bit more applied. On the pure-science side, I’m interested in natural molecules produced by phytoplankton, microscopic floating plants in the ocean, in terms both of the biogeochemistry of the oceans and the impact these molecules have on the carbon cycle, and ultimately on climate change. Phytoplankton take up carbon dioxide and convert it into organic compounds. When phytoplankton die or are eaten, these compounds often sink and become locked-up in the seabed sediments.
On the more applied side, I’m also very interested in what these natural products can do for society. Many land plants have already been studied in terms of their drug potential. But the marine environment hasn’t been studied in the same way. It’s an untapped resource and there are compounds just waiting to be discovered. It’s the marrying of these pure and applied areas of science that I really enjoy.

Although some of my work—in particular my work on UV absorbing compounds in phytoplankton—has turned out to have commercial implications, the discoveries wouldn’t have been made if I hadn’t been supported by funding from government research councils such as NERC. Industry wouldn’t have funded my fundamental research in biogeochemistry, and if I hadn’t had that grounding I wouldn’t have been able to go off into these different areas that have commercial potential. I think it is extremely important for the government to fund blue-skies research: after all, things like climate change affect us all.

(e) Kate Evans-Jones: global view

Kate Evans-Jones (figure 5) has an MEng degree in electronic engineering from the University of Wales Swansea as well as an MSc in marine resource management from Heriot-Watt University in Edinburgh. After completing PhD research in remote sensing at Swansea in 2000, she was offered a job at the Plymouth Marine Laboratory. Now 32 years old and working as a remote-sensing-development scientist, her research is supported by the NERC. It is an environment that suits her down to the ground.

Remote sensing is a vital tool for helping us to understand and respect our environment and the world we live in. I see it as really important because it gives us a global view of our world and maybe brings things
back into focus again. Remote sensing really does make you think about a more global idea, and I think that is very important for all science, to figure out how it all fits in with our world and what we are doing now and what we are providing for future generations. It’s a stimulating area to work in because we are still developing new uses for it. And I’ve always had this fascination with seeing the Earth from space.

My job is quite varied and involves development work to improve the quality of remote-sensing data and finding new uses for them. The data are used for all sorts of things, for example, to complement the data collected by scientists out on ships. It’s also used in modelling to gain an understanding of things like climate change. The better the data we can provide, the better those models will work.

I see myself as playing a really important supporting role: effectively I’m working across a wide range of disciplines, something that I would find difficult to do without support from bodies like the NERC. I think it is very important that people are aware of the possibilities of moving across the disciplines and using their skills in something else to support science that other people are doing.

I really enjoy the global focus and it helps to fulfil my desire to use engineering in an environmental context. And, of course, it’s very satisfying when you get remote-sensing data out and see them being used. Recently, I was involved in providing real-time data for Mount Etna when it erupted. I found it quite exciting to work with the scientists studying the volcano and to provide them with the data they needed so that they could combine our satellite data with their ground-monitoring data to monitor the situation. I find it really satisfying when people discover a use for our data and we can help with their work.

(f) Mike Siva-Jothy: mining knowledge

Mike Siva-Jothy (figure 6) caught the insect ‘bug’ as a zoology undergraduate at UCL and went on to study insect physiology as a means of understanding the mechanistic basis of evolutionary phenomena, particularly behaviour. Following postdoctoral research in Japan and at UCL, he was offered a job at the Department of Animal and Plant Sciences at the University of Sheffield. Now, at 42, he is a senior lecturer with a tenured job.

The luxury of having a tenured job is that you can pretty much do what you like research-wise. Around 10 years ago I got interested in insects, immunity and sexual selection. Ironically, this is now turning into an important field of research. In my research group we are trying to understand the life-history decisions that insects are making in response to parasite threats. We’re not looking at malaria or specific parasite-related diseases. Instead we’re looking at models to get a handle on how an insect host decides how it is going to invest in immunity. Short-term goals for us are to start piecing together how the insects’ immune system is actually coordinated. Just understanding that is important. There is no way that you are going to get to the Holy Grail in Palestine unless you choose the
right footwear, and at the moment the footwear is pretty important to us. Mid- and long-term goals are really about looking at how all of this links together in a life-history sense and in the field.

The thrill of doing research—of discovering things—is a great motivation for me, as it is for many scientists. As I see it, people like me are effectively gem miners: we have no definite goal, other than to turn up rough gems. The difference between us and real gem miners is that they know what they are looking for. We often don’t, so have to develop the nous to spot something valuable. Once we have found our gems, we pass them on to the merchants—the applied scientists—who cut them and make them into a useful, even beautiful, commodity. Finally, the jewellers, that is, industry, turn them into something the public wants and sees as useful.

I don’t have a problem justifying and applying for funding for pure research, because if you look at the track record of important applied discoveries, they [the discoveries] are invariably made by people working on what research councils would consider to be pointless science. Pure science really is like mining; you have to sift through a lot of material before you find the real nuggets. And it’s not apparent where they are going to be.

I think the NERC is doing an extremely good job of balancing the need to support very high-quality science with no apparent immediate application with the need to justify our existence and the fact that they can address issues that are important at the moment. Twenty years ago, it was less apparent why we should be spending a lot of money looking at patterns of climate change, and suddenly it’s become a major issue.