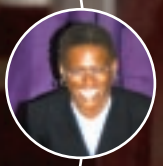
sciencescotland from The Royal Society of Edinburgh

The best of Scottish Science and Technology

ISSUE 2 - SPRING 2004

Optical Communications



Drug delivery systems

Designing in a virtual world

www.sciencescotland.org

Introduction

I very much welcome the opportunity to introduce this second edition of 'Science Scotland', which is helping to promote Scotland's exceptional science capabilities around the world.

Science in Scotland is built on firm foundations, with many world-changing discoveries and inventions having been made by Scots. Today our universities and research institutions are continuing on this path of excellence - for instance, the Scottish research base produces 1% of the world's published research with less than 0.1% of the world's population. This ranks us in the top three in the world in terms of scientific publications per capita. Nearly half of the research in our universities was classed as internationally competitive in the UK's last research assessment exercise.

We have confirmed the vital role of science for our future economic success and in raising quality of life through our Science Strategy for Scotland, published in 2001. We have committed robust funding of the research base in order to maintain its international competitiveness, and we have set up an independent Scottish Scientific Advisory Committee to advise us on strategic funding priorities.

Recognising the vital importance of harnessing the wealth of innovation in our research base we have introduced a range of initiatives such as the Proof of Concept Fund, the Scottish Co-investment fund and Enterprise Fellowships. The establishment, by Scottish Enterprise, of three Intermediary Technology Institutes in energy, digital tech media and biosciences with funding of £450 million over the next 10 years also represents a major commitment to developing our knowledge economy.

We certainly warmly welcome all those from overseas who are able to help develop our science base and connect it even more fully to the international science community. I do hope that through "Science Scotland" you will be tempted to find out more about the science and research opportunities in Scotland.

Best wishes,

Jim Wallace

Deputy First Minister and Minister for Science

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Through a glass darkly

A team that includes contributors from the University of Edinburgh has finally been able to provide a definitive answer to an old bar-room puzzle.

Anyone who enjoys a glass of beer has probably noticed the strange effect that seems to show bubbles sinking through the liquid as the head in the beer settles. Whether this is fact or illusion it has been the cause of many a good natured debate. Well, help is at hand!

The beer contains dissolved gas which, when it comes out of solution, seeks to rise up. However the liquid in contact with the edges of a glass has restricted movement, due to friction with the sides of the container, so the central column of liquid rises more easily and quickly. In turn this sets up a circular movement in the beer rather like a convection current. The liquid at the sides of the glass moves downward and can pull the bubbles down with it. The effect is enhanced if the bubbles are small and the bubbles are easier to see if the beer is dark. Consequently, beers with nitrogen dissolved in them are more likely to show this effect than those with just carbon dioxide.

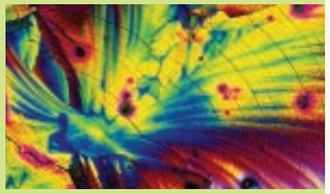


Image courtesy of Michael Davidson at Florida State University

"A micro-photograph of a famous stout"

Now – if you could please just bring me another glass of stout.....

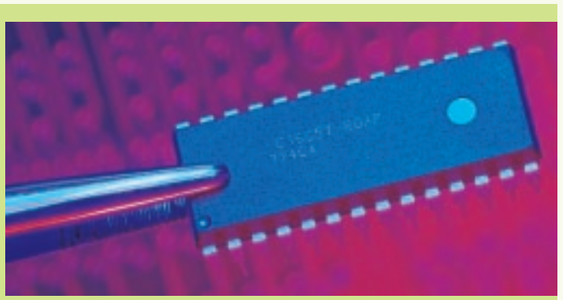
(http://www.chem.ed.ac.uk/guinness/)

Technology Transfer & Innovation in Edinburgh

Leading Speakers from the fields of academia, the public sector and industry meet this summer for three days in Edinburgh

The Edinburgh International Conference Centre plays host to TTI 2004 (http://www.tti-ltd.com/) between 29th June and 1st July this year. Over the three days the conference will discuss issues ranging from the creation and transfer of knowledge, through to the commercial exploitation of the physical sciences. The event will be opened by Jim Wallace QC, Science Minister and will conclude with a conference reception to be held in Edinburgh Castle.

Glasgow leads the way in a £4.5 million microchip development project



A major, international collaborative project between the University of Glasgow and Motorola Ltd is set to develop the next generation of microchips.

Backed by £4.5 million funding, a team led by Professor Iain Thayne of the University of Glasgow will develop high speed, high performance chips from innovative new materials and processes. Shrinking the traditional silicon-chip based technology has technical limitations below a certain size. The Glasgow-based researchers anticipate that these new devices will have at least twice the performance of their traditional, silicon-based equivalents, thereby overcoming the technology bottleneck currently faced by the industry. Seven University of Glasgow research groups within the Departments of Electronics and Electrical Engineering and Physics and Astronomy will combine their expertise with intellectual property transferred from Motorola to develop various areas of research including compound semiconductor materials growth and characterisation and nano-fabrication technology.

Professor Iain Thayne explains:
"This collaboration is an excellent example of an industrial and academic working partnership. It will place the University of Glasgow firmly on the map in global semiconductor research and development, our complementary areas of expertise will allow us to address some of the major challenges currently faced by the semiconductor industry."

(http://www.gla.ac.uk:443/newsdesk/newsletter/)

Stem Cell Sciences returns to Scotland

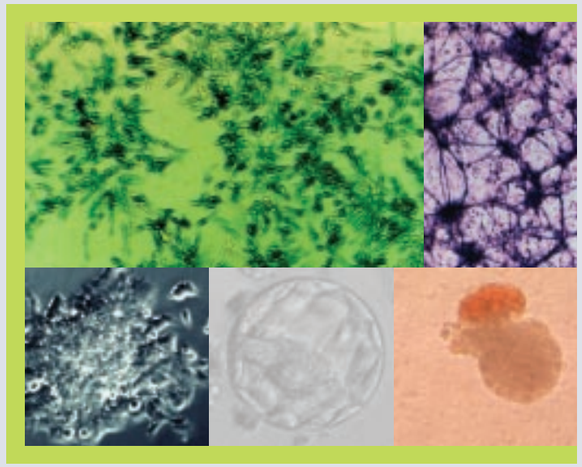
Peter Mountford, Chief Executive Officer of Stem Cell Sciences has announced the company's return to Edinburgh. Stem Cell Sciences is recognised as one of the world's leading authorities on Stem Cell research.

Their pre-eminence in the field is clearly demonstrated in scientific publications of their affiliated academic colleagues dating back to the late 1980s. In addition to the recently established head office and laboratories here in Edinburgh, SCS also has offices and laboratory facilities in Melbourne (Australia) and Kobe (Japan).

Stem cells are derived from human and animal embryos before the cells of the embryo have committed to becoming any specific cell type and can be grown in a laboratory in an essentially unlimited supply. The cells can then be 'differentiated' so as to provide virtually any cell type found in the body including nerves, heart, blood, bone, cartilage and even islet cells for diabetes, promising a revolution in human medicine.

Peter explained why the company has decided to make the move:

"I first came to Edinburgh to study with Professor Austin Smith FRSE, the Director of the University of Edinburgh's Institute for Stem Cell Research (ISCR) in 1991. He's been the intellectual driver of the science behind SCS since 1994 when the company was founded in Melbourne. I was funded by a Royal Society Endeavour Scholarship for my 2 year postdoc here with Austin."



"Stem Cell Sciences' principal objective is to be the first company to deliver clinical benefit from an Embryonic Stem cell-derived cell therapy. This requires multiple technologies and a globally integrated initiative. No one company or country can hope to deliver the whole package of technologies needed all on their own. The cutting edge of ES cell research is firmly based in Edinburgh with Professor Austin Smith and his team with whom SCS enjoys an exceptional relationship with the ISCR as their preferred commercial partner in the stem cell field."

"We feel that a base in Edinburgh allows us to be close to our academic colleagues and also the heart of the European pharmaceutical and investment markets. Not only that, so many breakthroughs in this area have been the product of Scotland. It's only right that SCS should be here and that this country should benefit."

"SCS also has strong links with the RIKEN Centre for Developmental Biology (CDB, Kobe Japan) through its affiliated Japanese company SCS KK. SCS and the Edinburgh based academic researchers at the ISCR have close working relationships with leading researchers at the RIKEN CDB. The institute is a major component of the Kobe Frontier Medical Precinct and Scottish Enterprise is hoping to create a similar facility here based around the new Royal Infirmary at Little France"

So are Stem Cell Sciences here to stay?

"I hope so" says Peter "We've moved the six members of our family and another Australian family of five over here so I don't think we'll be moving back again in a hurry!"

The Push and the Twist in a Beam of Light

Professor Miles Padgett has been interested in one thing over the last decade: light. Based at Glasgow University, he's been studying how light behaves and he's made some interesting discoveries. Most of us know that light, just one portion of the electromagnetic waves flying through space, has a unique mix of ray, wave or quantum properties in the visible spectrum. But Miles has been delving deeper and deeper into exactly how light behaves and how its unique properties can be better understood and put to use.

The fundamental basis of his research is the fact that light has momentum.

"Light actually has momentum. This is something we've known about since Keppler in the 1600's. What that means is that if I shine a light at you, you'll be very slightly pushed back by it. What they didn't know in the 1600's is that light also has angular momentum. You'll not only be pushed very slightly backwards by the light beam, you'll also be pushed slightly to one side. The beam has linear and angular momentum."

"Of course you're such a large object that the effect is infinitesimal, but if we shine a light beam on very small particles we can see the effect quite clearly."

Angular momentum has two key components: spin angular momentum and orbital angular momentum. The spin angular momentum of the earth is what gives us night and day: the earth spins and presents a changing face to the sun. Spin is a fundamental property of all elementary particles, and is present even if the particle is not moving. Orbital angular momentum however, results from a particle moving around something, like an electron around a nucleus. Orbital angular momentum gives us the seasons as the earth moves around the sun.

Orbital angular momentum results from the motion of a particle.

For example, an electron in an atom has orbital angular momentum, which results from the electron's motion about the nucleus, and spin angular momentum. The total angular momentum of a particle is a combination of spin and orbital angular momentum.

Light possesses both spin angular momentum and orbital angular momentum. Because angular momentum can never be 'created', only exchanged, just like energy, the absorption of a photon by a microscopic particle results in the photon's angular momentum being transferred to the particle, which will start to spin as a result.

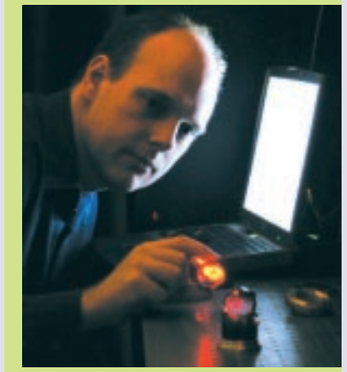
By shining a tightly focused light beam down a microscope onto tiny microscopic particles, less than 1000th of a millimetre across, Professor Padgett has been able to demonstrate the effect of both forms of angular momentum on particles.

The spin angular momentum of light is a result of the polarisation of individual photons of light, and physicists have known about the spin angular momentum of light since the 1900's . The polarisation vector rotates in the transverse plane so the light beam possesses spin angular momentum in much the same way that rotating masses do. When this spin is transferred from light to a particle, the particle spins about its own axis, just like a spinning top.

In 1992, a team lead by Les Allen found the theoretical possibility that Laguerre-Gaussian light beams, a special type of laser beam with an intensity structure symmetric about the beam's axis, also possessed Orbital Angular Momentum. Since then, several groups have demonstrated the mechanical effects of orbital angular momentum on particles. Unlike spin angular momentum, when orbital angular momentum is transferred from a light beam to a microscopic particle, the particle does not spin on its own axis, it "orbits" about the beam's axis .

This has been demonstrated very elegantly by Professor Padgett's team and as a result they have developed what they refer to as an "Optical Spanner". A tightly focussed laser beam has momentum and the force of this momentum is strong enough to 'trap' small particles in the beam, allowing the particle to be positioned in three dimensions. Where the same light beam also transfers some of its angular momentum to the particle, the particle can be spun in a controlled manner and aligned directionally. Effectively the beam is a microscopic tool that can not only hold microscopic particles still, but also rotate them about the beam's axis, potentially a very useful device. It's possible to imagine a future where the same technology is used for a whole range of purposes from driving micro machines to running tiny pumps.

The Orbital Angular Momentum of light beams has equally interesting applications within the field of communications. Light beams are already used to transmit data in the modern world and at the moment there are two ways of doing this: one is to shine a light down an optical fibre and the second is simply to shine a light through the air.

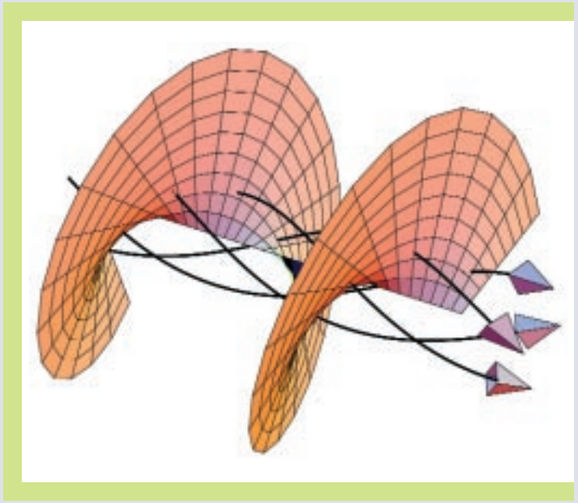


The disadvantage to the last method is that the information is there for anyone to see and pick up. Spin angular momentum is already used in quantum cryptography to encode information but spin angular momentum only has two distinct states: left or right hand circular polarisation. Information can be coded using these two states but this is a laborious method of transmitting data, much like using Morse code, with only a dot or a dash to work with.

Orbital Angular Momentum is a much more useful property for communication with a number of distinct advantages. A single photon has, potentially, an infinite number of distinct Orbital Angular Momentum states. Information can therefore be encoded in the 'twist' of light, multiplying the number of distinguishable states and giving a major bandwidth advantage. In principle, a single photon can carry an arbitrarily large amount of information. While the possibility of such a method of transmitting information has been recognised for some time it wasn't until Professor Padgett and his team started working on the problem that a viable method for distinguishing all the possible different Orbital Angular Momentum states with efficiency was developed.

At the time the team were working on a different problem but it became apparent that a method for measuring the Orbital Angular Momentum of individual photons would not only be useful for the work in hand but would also have a multitude of interesting practical applications. Johannes Courtial, one of the team members came up with a design for the Orbital Momentum Angular sorter over a couple of days and the team have now developed the sorter to the point that they are able to transmit information from one end of a 20m corridor to another.

The sorter works by routing light beams, and in fact, individual photons, into different 'output ports' according to their



degree of 'twist'. Light passes through a series of interferometers, and each sorts the photon into one of two different classes. In principle, the number of output ports can be arbitrarily large and the device 'sorts' with perfect efficiency. The team still have quite a lot of work to do before they can produce results from their sorter to match the theoretical possibilities but the potential for useful applications of the technology is huge.

Miles predicts that in the future a sophisticated array of 'torches' mounted on the tops of high buildings will be able to send vast amounts of information without the need for expensive cable laying. In theory light beams will have eight times the capacity of fibre optic cable, thanks to the unique properties of the 'twist' the in the beam due to its Orbital Angular Momentum. And because information is transmitted using this 'twist' in the light, data will also be completely secure.

"It's an innate property of the twist that you can only measure it if you are sitting where the receiver is. If you're off to one side you can't measure it" says Miles.

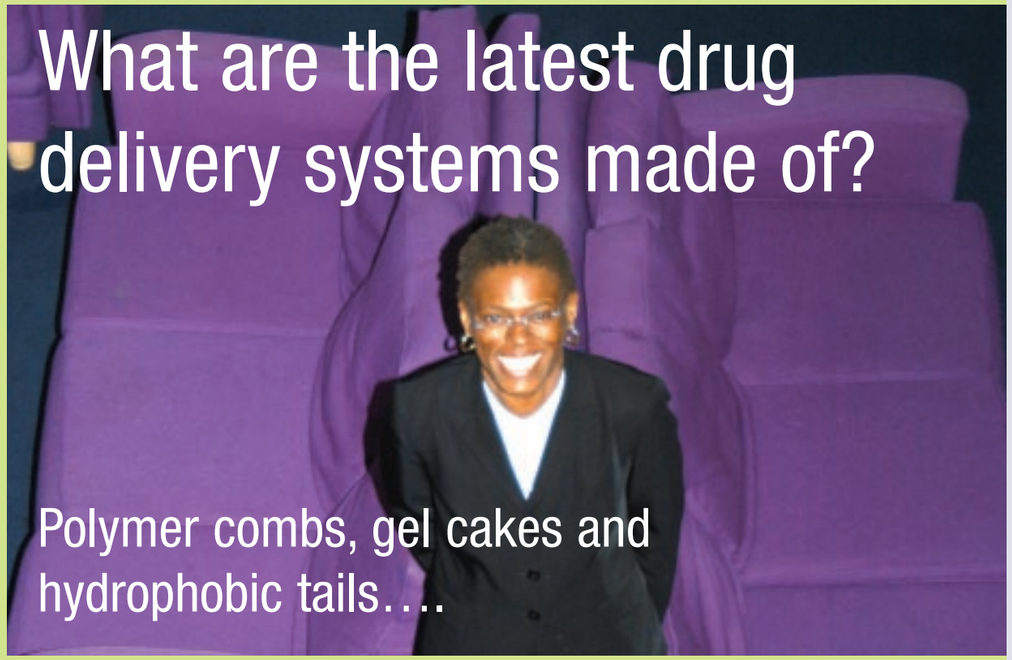
The next step for the team is to test their theories by moving their demonstrator from the corridor onto the University roof tops.

"We know that at the moment we're the only people using this particular technology but there are lots of companies using wireless technology that may be very interested in what we're doing."

And in the future we could be living in a world where our communication networks are a grid of light in the sky instead of a mass of wires underground.

And all because a team in Glasgow worked out how to measure the twist and the thrust in a beam of light…

(http://www.physics.gla.ac.uk/Optics/Miles/)



Professor Uchegbu and her team at Strathclyde University have been using water soluble biopolymers attached to hydrophobic chains to create self assembling systems for drug delivery.

Using this method she can control where a drug goes in the body, (particularly vital when a drug may be toxic and needs to be accurately targeted to a specific place like a tumour) and the speed at which the drug is released.

The polymer self assembles in water to protect the hydrophobic 'tail' attached to it. The polymer is a bit like a comb, a molecular comb, with the polymer as the backbone and the hydrophobic tails as the teeth. The team have been working with polymers with low, medium and high levels of hydrophobic tails attached and depending on the ratio, the polymer will self-assemble into different architectures when added to water.

With a high number of hydrophobic chains, the polymer coalesces into a gel and can be used as a method of delivering drugs to the body. Other teams around the world have been able to load 4-5% of a gel with a treatment drug, using a cross linking agent to covalently bind the polymer chains. The reaction which creates the covalent linkages could destroy a drug added to the gel so most producers must make the gel first and then add the drug afterwards. Professor Uchegbu's team have come up with a whole new way of creating the polymer gel which allows for a far higher percentage of the gel to be loaded with the drug.

"It's a bit like baking a cake" says Professor Uchegbu

"You start off with a wet mixture which you put in the oven and after it's baked the water has been largely removed by the baking process and the mixture is all stuck together. We do the same thing with our polymer gel. We put the drug into the mix with the polymer and the hydrophobic tails, then remove the water by freeze drying.
The hydrophobic tails hold the polymer together so no covalent linkage is required. Because we add the drug before the gel is formed, we can load upto 40% of the gel with the drug. The gel will rehydrate in the moist environment of the body and gradually release the drug. Increasing the number of hydrophobic chains slows down the drug's

release into the body so it's possible to control the rate at which the drug is released quite accurately."

Add intermediate levels of hydrophobic chains and the polymer will create vesicles: small bubbles or sacs which form around the hydrophobic chain to protect it from the water. It is possible to place drug molecules within the vesicles and in this way deliver the drug to the patient. The size of the vesicle can be controlled by dictating the molecular weight of the polymer and this ability to control the size of the vesicle can be used to dictate which blood vessels the vesicle can pass through. Vesicles can be created which are too large to pass through the narrow blood vessels in healthy tissue but which are able to permeate the wider vasculature of a tumour. The vesicle is therefore a useful vehicle for drug delivery, transporting drugs more easily across the cell membrane and could be particularly useful in delivering drugs which are difficult to get into a cell with existing methods. The team also undertook research to look into the possibility of using vesicles to deliver genes directly into cells but so far this area has met with more limited success. Associating the drug encapsulated within the vesicle with DNA, however, allows the drug to be specifically targeted to an area within the body.

With a low number of hydrophobic chains the polymer doesn't self assemble in water, despite the presence of hydrophobic groups and instead becomes soluble. This allows potential for delivering a drug to the body which is not normally soluble in water. Within the solution, invisible to the eye, tiny micelles are formed to shield the hydrophobic content. These micelles act as a hydrophobic pocket into which a drug can be put. This method of drug delivery has major advantages as at the moment the only successful method for delivering non-water soluble drugs is by using organic solvents. These can be highly toxic for the body and the solution created by Professor Uchegbu's team would overcome this issue admirably.

Working at the forefront of pharmaceutical research the team are also investigating small star shaped molecules called dendremas to efficiently deliver genes to specific areas in the body. At the moment chemicals used to deliver genes tend to allow gene expression in the blood vessels of the lungs, which limits the kinds of diseases which can be targeted. Professor Uchegbu's team use molecules with very small molecular weight and they are able to deliver genes into the liver which is a much more useful area of the body in terms of the number of diseases which can be targeted and can allow gene expression to take place directly within tumours.

With such a range of useful areas within her remit Professor Uchegbu is an asset to Scotland and the world of drug delivery systems. One day many of us may benefit from the fruits of her labours, although hopefully not too soon!

(http://www.strath.ac.uk/pharmsci/staff/uchegbu_i.htm)

Designing in a Virtual World

Architects have created a virtual world where they can work on their designs, collaborate with colleagues, walk through a simulation and dynamically make changes.

Sustained research and development by a team of architects at the University of Strathclyde has established that Virtual Reality now has an application at the initial design stages of a project. Professor Tom Maver, Emeritus Professor at the Department of Architecture and Building Science, explained the benefits of working in a virtual world.

Computer Aided Architectural Design (CAAD) has become common practice in recent years as a valuable approach to creating virtual models and making presentations to clients once the design stages of a project are largely complete. However, the labour-intensive nature of developing a detailed Virtual Reality (VR) environment has made its use impractical in the early stages of project development.

Now, as the next generation of design tools emerge, the ABACUS team at Strathclyde has established that the virtual world can provide a powerful design environment that encourages collaboration, supports creativity and eases the process of making changes to the model. Ultimately this will allow clients and users far more participation in the design of buildings: they will be able to gain a meaningful insight into the architect's ideas and have a natural vehicle for response.

"A good example of this can be seen in work carried out in the department to design a leisure centre for wheelchair users," explained Tom Maver. "In the virtual environment, the designer was able to put himself in the position of the wheelchair user and experience how the space would work from that perspective. This helped to identify the appropriate gradient for ramps, the positioning of louvres on the windows and the location of sensors for automatic doors."

The virtual reality design environment, JCAD-VR, which has been developed at the Department of Architecture and Building Science,

uses a client-server architecture to allow constant synchronous collaboration between several users. An innovative multi-platform design was made possible by the use of Java3D as the development language. This means that JCAD-VR can be used successfully both with the multi-projector display system in the world class Virtual Environment Laboratory at Strathclyde University, and on a home PC. There are also modules that allow for the use of VR helmets, gloves and other devices that may be more familiar in a computer game setting.

"The significant advance", says Prof Maver, "is that designers can now interact within the virtual world and make changes synchronously. Previously, an architect would step into the virtual world, take a look and step out again. Discussions and changes would be made in the real world and the iterative process could be arduous. Designing within the virtual world, however, is an immersive experience which has a positive impact on creativity." JCAD-VR allows several users to meet inside the virtual world. As well as a figure that represents each participant moving through the virtual environment, there can also be video conferencing running within the programme.

Another innovative feature of JCAD-VR is that the Graphical User Interface (GUI) exists within the 3D virtual environment. Participants can control the programme and make design changes using 3D icons, without ever leaving the VR world.

Some of the significant advances in virtual reality applications have come through collaboration with other departments at Strathclyde University. A platform that allows wheelchair users to experience the Virtual Environment Laboratory was developed in association with the Strathclyde Bioengineering Unit, with funding from the Engineering and Physical Science Research Council. The platform accommodates a wide range of manual wheelchairs and allows the user to navigate within virtual worlds, experiencing force feedback as inclines and changes in surface texture are encountered. Users have commented with enthusiasm on the high degree of correspondence with the real world. The Virtual Environment Laboratory has 150 degrees of screen and multiple projectors; it creates a genuine sensation of being inside the virtual world.

Further collaboration has led to establishing closer links between CAAD modelling and the production of physical 3D models. Working with Strathclyde University's Rapid Design and Manufacturing Centre, architecture students have been able to produce physical models direct from the computer data using a 3D printing technique which draws with latex on layers of powder in much the same way as a 2D plotter draws with ink on successive sheets of paper.

The introduction of a third technology, laser scanning, makes it possible to scan a physical model and create a digital reconstruction. "The Computer Graphic – Physical Model – Laser Scan triangle will allow designers to work in the medium where they are most creative, but without significant time loss or expense if work has to be translated into another form. The other main advantage is that it becomes possible to make changes in one format and update the other," says Prof Maver.

"Again this is the kind of development that enriches opportunities for architects within the design process. It is an emerging technology and work is still required to ensure the compatibility of data formats, and to deal with issues of occluded geometry that can occur during the laser scanning."

Two of the most significant benefits of the advances in design techniques are in the areas of client involvement and in creating sustainable buildings. As it becomes easier for clients and users to see and experience what a building will be like, there will be better opportunities for the architect to creatively interpret the client's ideas and deliver upon expectations.

On the sustainability front, VR can play a vital role in measuring the energy a building will use and exploring ways of continually improving efficiency. Prof Maver adds, "And of course, the most sustainable building of all is a virtual building!"

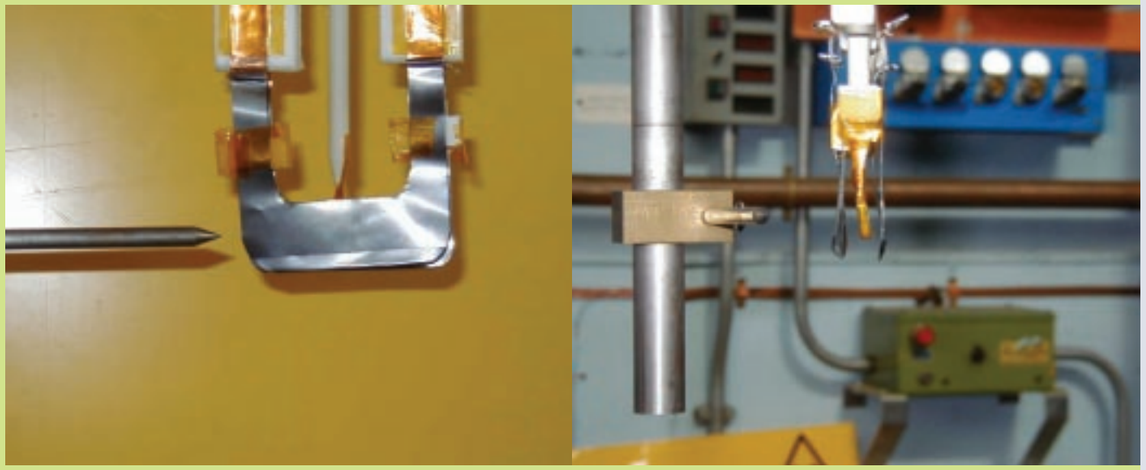
The innovative iterative design techniques being developed by the ABACUS team provide advanced levels of precision and control throughout the design process. VR is proving to be more than a presentation medium, offering an investigative environment that stimulates both practical solutions and creativity.

Since its inception in 1968, ABACUS (Architectural and Building Aids Computer Unit, Strathclyde) has established an international reputation for the use of computers in architectural research, teaching and practice. In a recent Research Assessment Exercise, the team was given a 5 star rating, equivalent to international excellence. A leading player in this fast-developing field, ABACUS aims to meet the growing demands from the construction industry for specialised computing skills and relevant application programs.

Collaboratively with the Bioengineering Unit at the University of Strathclyde, ABACUS has developed a wheelchair motion platform for use in the Collaboratively with the Bioengineering Unit at the University of Strathclyde, ABACUS has developed a wheelchair motion platform for use in the Virtual Environment Laboratory. The platform accommodates a wide range of (manual) wheelchairs and allows the user to navigate within virtual worlds while experiencing force feedback as inclines and changes in surface texture are encountered. User evaluation of the facility indicates a high degree of correspondence of the experiences of the virtual world with the real world.

(http://iris.abacus.strath.ac.uk/new)

Taking Microwave Cooking to Extremes



Professor Andrew Harrison works at the Centre for Science at Extreme Conditions, based at the University of Edinburgh with his partner Gavin Whittaker. The centre focuses its activities on the study of materials at extremes of pressure, temperature and electromagnetic fields. It's multi-disciplinary with research interests ranging from fundamental physics, chemistry and biology, through geoplanetary and materials science, to engineering and technology.

Part of Professor Harrison's research is concerned with an important, emerging technique in materials synthesis: the use of microwave radiation to accelerate reactions or enable processes not found under conventional heating. He looks at the effect of extreme electromagnetic fields on materials and biological tissue. Using technology we've had in our kitchens for the last fifty years he devises devices which can deliver controlled levels of power and follows what happens during the radiation process. One area of his research uses very small levels of microwave radiation targeted at protein molecules.

"We're looking at subtle changes in protein molecules and membranes while they're irradiated gently with microwaves" he says

"The levels are so low they don't heat the molecule significantly but they excite the material. By undertaking this research we can add to the debate, which surrounds the use of mobile phones, and their effect on the human brain. At the moment almost all the evidence pointing to brain tumours linked to mobile phone use is purely statistical. This research allows us to actually see the effect of low level microwave radiation on biological material."

At the other end of the spectrum Professor Harrison's team are using huge doses of microwave radiation to heat a substance which most of us avoid putting anywhere near microwaves.

"We're all familiar with the fact that metals will spark if placed in a microwave. This is because microwaves are actually very selective in what they heat. A glass container of plastic will remain cool but a metal will heat up rapidly. This allows us to do what I call smarter chemistry." The team have been particularly looking at practical applications for their research. One example cited is the fact that a catalytic converter doesn't actually start working effectively until it has heated up. This leaves a dead time of ten minutes during which the converter will not be working. Professor Harrison believes this could be an opportunity to use smart chemistry.

"Using microwaves to heat the metal would ensure the converter was working immediately the car was started. This is just one example of the ways that microwaves can be used when there's an advantage to heating part of something. Our research is mainly aimed at following what happens when microwaves are used on a broad spectrum of materials, including biological materials but we're sure that out of this research numerous practical applications will be discovered, applications where we can be clever in our use of microwaves and achieve results which could not be gained any other way."

Professor Harrison was keen to emphasise that his research is just a small portion of the work undertaken at the Centre for Science at Extreme Conditions however, his research promises interesting results and could see microwaves being used in all sorts of surprising places, and not just in the kitchen.

(http://www.csec.ed.ac.uk/)

Forthcoming Events

Title Event	Date	Venue
Edinburgh International Science Festival *www.explore-edinburgh.com*	3 - 14 April	Venues throughout Edinburgh
Fire and Structures – Implications of the World Trade Centre disaster *www.royalsoced.org.uk*	21 April	The Royal Society of Edinburgh
Aquaculture International 2004 *www.secc.co.uk*	19 - 21 May	Scottish Exhibition and Conference Centre
International Conference & General Meeting Of Euspen *www.euspen.com*	31 May - 2 June	Scottish Exhibition and Conference Centre
TTI Conference *www.tti-ltd.com/tti2004/*	29 June - 1 July	Edinburgh International Conference Centre
Edinburgh International Festival *www.eif.co.uk/*	15 Aug - 6 Sept	Venues throughout Edinburgh

Directory: Universities

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22-26 George Street, Edinburgh EH2 2PQ
Tel 0131 2405014 Fax 0131 2405034
E-mail adavidson@scottishscience.org.uk
www.scottishscience.org.uk

The SSAC is a new and independent voice for Scottish science. It provides independent advice to Scottish Executive ministers on strategic scientific issues. The broadly based Committee is uniquely placed to take an overview of the broad and diverse scientific landscape in Scotland and to place this in an international perspective.

University of Aberdeen
Regent Walk ABERDEEN AB24 3FX T: 01224 272000 W: www.abdn.ac.uk

University of Abertay
Dundee Bell Street DUNDEE DD1 1HG T: 01382 308000 W: www.abertay.ac.uk

Bell College of Technology
Almada Street HAMILTON ML3 0JB T: 01698 283100 W: www.bell.ac.uk

University of Dundee
Perth Road DUNDEE DD1 4HN T: 01382 344000 W: www.dundee.ac.uk

University of Edinburgh
Old College South Bridge EDINBURGH EH8 9YL T: 0131650 1000 W: www.ed.ac.uk

Edinburgh College of Art
Lauriston Place EDINBURGH EH3 9DF T: 0131 2216000 W: www.eca.ac.uk

University of Glasgow
GLASGOW G12 8QQ T: 0141 339 8855 W: www.gla.ac.uk

Glasgow Caledonian University
70 Cowcaddens Road GLASGOW G4 0BA T: 0141 331 3000
W: www.gcal.ac.uk/home_dhtml.html

Glasgow School of Art
167 Renfrew Street GLASGOW G3 6RQ T:0141 353 4500 W: www.gsa.ac.uk

Napier University
Riccarton EDINBURGH EH14 4AS T: 0131 449 5111 W: www.hw.ac.uk

University of Paisley
High Street PAISLEY PA1 2BE T: 0141 848 3000 W: www.paisley.ac.uk

Queen Margaret University College
Clerwood Terrace EDINBURGH EH12 8TS T: 0131 317 3000 W: www.qmuc.ac.uk

Robert Gordon University
Schoolhill ABERDEEN AB10 1FR T: 01224 262000 W: www.rgu.ac.uk

Royal Scottish Academy of Music and Drama
100 Renfrew Street GLASGOW G2 3DB T: 0141 332 4101 W: www.rsamd.ac.uk

Scottish Agricultural College
The Kings Buildings West Mains Road EDINBURGH EH9 3JG T: 0131 535 4000
W: www.sac.ac.uk

University of St Andrews
St Andrews FIFE KY16 9AJ T: 01334 476 161 W: www.st-andrews.ac.uk

University of Stirling
STIRLING FK9 4LA T: 01786 473 171 W: www.stir.ac.uk

University of Strathclyde
GLASGOW G1 1XQ T: 0141 552 4400 W: www.strath.ac.uk

UHI Millennium Institute
Caledonia House, 63 Academy Street, INVERNESS IV1 1BB T: 01463 279000
W: www.uhi.ac.uk

Open University in Scotland
10 Drumsheugh Gardens EDINBURGH EH3 7QJ T: 0131 226 3851 W: www.open.ac.uk

Directory: Research Institutes

SEERAD Agricultural and Biological Research Group (ABRG)
Room 434, Pentland House, 47 Robb's Loan
Edinburgh EH14 1TY
Tel 0131 244 6057 Fax 0131 244 6566
www.scotland.gsi.gov.uk

The ABRG funds a range of basic, strategic and applied research in the agricultural, biological, environmental and related life sciences. Research is conducted primarily through the five Scottish Agricultural and Biological Research Institutes (SABRIs), the Scottish Agricultural College (SAC), the Royal Botanic Garden Edinburgh (RBGE) and Biomathematics and Statistics Scotland (BioSS).

Hannah Research Institute
Ayr KA6 5HL
Tel 01292 674000 Fax 01292 674004
www.hri.sari.ac.uk

Founded in 1928, the Hannah Research Institute is an international scientific research centre focused on the biology of lactation and the use of milk in food products.

Macaulay Institute
Craigiebuckler, Aberdeen AB15 8QH
Telephone 01224 498200
Fax 01224 311556
E-mail enq@macaulay.ac.uk
www.macaulay.ac.uk

The Institute is now the premier centre for sustainable land use research in Europe, concerned with rural economic and community development and the protection and enhancement of natural resources. Research at the Institute is multidisciplinary across soil, plant and animal science, geography, socio-economics and IT areas.

Directory: Research Institutes

Scottish Agricultural Science Agency (SASA)
82 Craigs Road, East Craigs Edinburgh EH12 8NJ
Tel 0131 244 8890 Fax 0131 244 8940
E-mail info@sasa.gsi.gov.uk
www.sasa.gov.uk

SASA incorporates a community of around a hundred scientists and support networks, based in Edinburgh. The work of SASA biologists and chemists ensures the quality, safety and security of the food supply in Scotland, and protects the quality of the environment, in areas that have been devolved to the Scottish Executive.

Scottish Fisheries Protection Agency (SFPA)
Pentland House, 47 Robb's Loan
Edinburgh EH14 1TY
Tel 0131 244 6059 Fax 0131 244 6086
www.sfpa.gov.uk

The SFPA monitors industry's compliance with UK, EU and international fisheries laws and regulations in ports and at sea within British fisheries limits around Scotland and in international waters when required.

Roslin Institute
Roslin Biocentre, Midlothian EH25 9PS
Tel 0131 527 4200 Fax 0131 440 0434
www.roslin.ac.uk

The Roslin Institute is one of the eight research institutes in the UK sponsored by the BBSRC. A leading centre for research on farm and other animals, Roslin has internationally recognised programmes on molecular and quantitative genetics, genomics, early development, reproduction, animal behaviour and welfare and has pioneered methods for the genetic modification and cloning of farm animals. In 1996, Roslin and collaborators PPL Therapeutics created Dolly the sheep, the first animal cloned from a cell taken from an adult animal.

British Geological Survey
Murchison House, West Mains Road
Edinburgh EH9 3LA
Tel: (0)131 667 1000
Fax: (0)131 668 2683
E-mail: www-bgs@bgs.ac.uk
www.bgs.ac.uk

The aim of BGS is to advance geoscientific knowledge of the United Kingdom landmass and its continental shelf by systematic surveying, long-term monitoring, effective data management and high-quality applied research.

Dunstaffnage Marine Station
OBAN, Argyll, UK PA34 4AD
Fax: +44 631 65518.
Tel: +44 631 562244
E-mail: jama@dmf.ac.uk

The station is located on the shores of the Firth of Lorn, Argyll. The research programme includes the development and behaviour of herring, algal physiology, plankton and benthic ecology, and the taxonomy of coelenterates, ascidians and other marine invertebrates.

Royal Botanic Garden Edinburgh
20A, Inverleith Row, Edinburgh EH3 5LR
Tel 0131 552 7171 Fax 0131 248 2901
www.rbge.org.uk

The Royal Botanic Garden Edinburgh is a scientific institution pursuing research on the systematics and biology of plants that underpin other plant science and conservation matters.

Biomathematics and Statistics Scotland (BioSS)
The University of Edinburgh,
James Clerk Maxwell Building,
The King's Buildings Edinburgh EH9 3JZ
Tel 0131 650 4900 Fax 0131 650 4901
www.bioss.ac.uk

BioSS works in the field of mathematics and statistics applied to the biological sciences, and contributes research, consultancy and training to agricultural, biological and environmental research organisations in Scotland.

Fisheries Research Services (FRS)
E-mail enquires@marlab.ac.uk
www.marlab.ac.uk

Marine Laboratory
P.O. Box 101, 375 Victoria Road
Aberdeen AB11 9DB
Tel 01224 876544 Fax 01224 295511

Freshwater Laboratory
Faskally, Pitlochry, Perthshire PH16 5LB
Tel 01796 472060 Fax 01796 473523

FRS is an agency of the Scottish Executive. Its mission is to: 'provide science that is respected, relevant and responsive' to customers needs.
The Agency comprises two main laboratories; for marine issues (Aberdeen) and freshwater fish (Pitlochry).

Directory: Government Bodies

Scottish Agricultural College (SAC)
West Mains Road, Edinburgh EH9 3JG
Tel 0131 535 4000 Fax 0131 535 4246
E-mail information@ed.sac.ac.uk
www.sac.ac.uk

SAC has R&D resources, education and training provision, and expert advisory and consultancy services. Its research is mainly on agriculture and related sciences, rural business development and management, food chain quality and safety, and rural resource and environmental management.

Moredun Research Institute (MRI)
Pentlands Science Park, Bush Loan
Midlothian EH26 0PZ, Scotland
Tel 0131 4455111 Fax 0131 4456111
www.mri.sari.ac.uk

Work at MRI is generally concerned with the health and welfare of farm animals. Established in 1920, MRI is internationally recognised for its work on infectious diseases of sheep and other animals.

Rowett Research Institute
Greenburn Road, Bucksburn Aberdeen AB21 9SB
Tel 01224 712751 Fax 01224 715349
E-mail enquiries@rowett.ac.uk
www.rowett.ac.uk

Research at the Institute is split into four human and animal research divisions: appetite and energy balance; cellular integrity; development, growth and function; and gut microbiology and immunology. The Institute is driven by recognition of problems of over-nutrition being linked to certain diseases and changes and competition in agriculture.

Scottish Crop Research Institute
Invergowrie, Dundee DD2 5DA
Telephone 01382 562731 Fax 01382 562426
www.scri.sari.ac.uk

The Institute has eight research programmes set out across three main themes, related to agricultural, horticultural and industrial crops-including genetic modification issues.

The Scottish Parliament Public Information Service
Edinburgh EH99 1SP
Freephone 0845 2781999
E-mail sp.info@scottish.parliament.uk
www.scottish.parliament.uk

The main functions of the Scottish Parliament are: to hold the Scottish Executive to account by analysing its policies; to make laws on devolved matters by means of examining, amending and voting on Bills; to hold debates and conduct inquiries.

The Scottish Executive
E-mail ceu@scotland.gsi.gov.uk
www.scotland.gov.uk

There are six departments within the Scottish Executive, covering Enterprise and Lifelong Learning; Health; Justice; Education; Development; and Environment and Rural Affairs. There are also separate finance and central services divisions. Many of the research-active agencies of the Executive are present within the Scottish Executive Environment and Rural Affairs Department SEERAD

Scottish Executive Enterprise and Lifelong Learning Department (SEELLD)
Enterprise and Lifelong Learning Department Secretariat, The Scottish Executive,
6th Floor, Meridian Court
Cadogan Street, Glasgow G2 6AT
Tel 0141 248 4774 Fax 0141 242 5665
E-mail ceu@scotland.gov.uk
www.scotland.gov.uk/who/elld

SEELLD was formed out of the pre-devolution Scottish Office Education and Industry Department. SEELLD supports Scottish ministers' economic and industrial development, further and higher education, skills and lifelong learning plans and objectives.
Innovation Support
Innovation Support SEELLD runs a number of innovation support grant schemes to help SMEs to develop highly innovative products and processes to the benefit of the national economy.
Enterprise Network
Economic and skills aims are promoted by SEELLD through sponsorship of Scottish Enterprise and Highlands and Islands Enterprise and via their networks of Local Enterprise Companies (LECs). Energy and Telecommunications: While these are reserved matters, SEELLD does liaise with these sectors and with Whitehall to ensure that Scotland's interests are represented.

Scottish Higher Education Funding Council (SHEFC) and Scottish Further Education Funding Council (SFEFC)
Donaldson House, 97 Haymarket Terrace
Edinburgh EH12 5HD Tel 0131 313 6500
E-mail info@sfc.ac.uk
www.shefc.ac.uk & www.sfefc.ac.uk

SHEFC is an NDPB accountable to the Scottish Executive through SEELLD, established in 1992. It provides financial support for teaching, research and associated activities and assesses the quality of higher education supported by SHEFC.
SFEFC is an NDPB accountable to the Scottish Executive through SEELLD, which distributes funds to the 46 further education colleges in Scotland.

Scottish Qualifications Authority (SQA)
Hanover House, 24 Douglas Street, Glasgow G2 7NQ
Tel 0141 2422214 Fax 0141 2422244
E-mail helpdesk@sqa.org.uk
www.sqa.org.uk

The SQA, an NPDB of the Scottish Executive, is the national body in Scotland developing, accrediting, assessing, and certifying qualifications (excluding degrees).

Directory: Government Bodies

Scottish Enterprise
5 Atlantic Quay, 150 Broomielaw Glasgow G2 8LU
Tel 0141 248 2700 Fax 0141 221 3217
www.scottish-enterprise.com

Funded by the Scottish Executive, Scottish Enterprise works with 12 local enterprise companies and the public and private sectors to make industries more competitive.

Scottish Development International
5 Atlantic Quay, 150 Broomielaw, Glasgow G2 8LU
Tel 0141 228 2828 Fax 0141 228 2089
www.scottishdevelopmentinternational.com

Scottish Development International is a Government-funded organisation working to promote Scotland's key strengths in knowledge-based industries, high-level skills, technology and innovation. The main aims of SDI are: to create partnership investments between Scottish and other companies, the SDI has 21 overseas offices.

Scottish Executive Environment and Rural Affairs Department (SEERAD)
Environment and Rural Affairs Department
Secretariat, The Scottish Executive
Room 440, Pentland House, 47 Robbs Loan
Edinburgh EH14 1TY
Tel 0131 244 6023 Fax 0131 244 6116
E-mail ceu@scotland.gsi.gov.uk
www.scotland.gov.uk/who/dept_rural.asp

SEERAD deals with policy advice and implementation in the areas of: agriculture, rural development, food, the environment, and fisheries. It sponsors and promotes the Scottish agricultural and biological science base. Additionally, SEERAD through ABRG, has responsibility for and funding commitments with a number of scientific research institutes in Scotland.

Scottish Executive Health Department (SEHD)
Telephone 0131 244 2440 Fax 0131 244 2162
E-mail ceu@scotland.gov.uk
www.scotland.gov.uk/who/dept_health.asp

The Scottish Executive Health Department (SEHD) is responsible for health policy and the administration of the National Health Service in Scotland. SEHD also has responsibility for the State Hospita and for NHS Health Scotland, which promotes positive attitudes to health and encourages healthy lifestyles.

Directory: Other bodies

Scottish Environment Protection Agency (SEPA)
SEPA Corporate Office,
Erskine CourtCastle Business Park, Stirling FK9 4TR
Tel 01786 457700 Fax 01786 446885
www.sepa.org.uk

SEPA is now responsible for the protection of the overall environment in Scotland, focusing on land, air and water, while working in partnership with others and towards a sustainable and diverse Scottish economy.

Scottish Natural Heritage
12 Hope Terrace, Edinburgh EH9 2AS
Tel 0131 447 4784 Fax 0131 446 2277
E-mail www.enquiries@www.snh.gov.uk
www.snh.org.uk

The aim of Scottish Natural Heritage is to promote care of a sustainable Scottish natural environment. The organisation engages in policy development, advice, some research, and guidance to the Scottish Parliament.

Scottish Water
PO Box 8855, Edinburgh EH10 6YQ
E-mail customer.service@scottishwater.co.uk
www.scottishwater.co.uk

Scottish Water provides water and wastewater services to household and business customers across Scotland (equal to around one third of the total land area of Britain). Scottish Water is public sector organisation directly answerable to the Scottish Parliament.

Forestry Commission GB and Scotland
231 Corstorphine Road, Edinburgh, EH12 7AT
Tel: 0131 334 0303 Fax: 0131 334 3047
Email: enquiries@forestry.gsi.gov.uk
www.forestry.gov.uk

The Forestry Commission is the Government Department responsible for forestry policy throughout Great Britain.
It has a Board of Commissioners with duties and powers prescribed by statute, consisting of a Chairman and up to ten other Forestry Commissioners, including its Director General, who are appointed by the Queen on the recommendation of Ministers.

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SCOTTISH EXECUTIVE

The Scottish Executive is the devolved government for Scotland. It is responsible for most of the issues of day-to-day concern to the people of Scotland, including health, education, justice, rural affairs, and transport.

BRITISH COUNCIL Scotland

The British Council Scotland enhances Scotland's international reputation and contributes to building an internationally-oriented, outward-looking Scotland.

SCOTTISH DEVELOPMENT INTERNATIONAL

Scottish Development International works to broaden Scotland's international appeal as a first choice source of knowledge from which to develop and exploit innovative technologies and ideas.

Register online at **www.sciencescotland.org** for regular updates, or complete and return this form to:
The Royal Society of Edinburgh, 22-26 George Street, Edinburgh, EH2 2PQ, United Kingdom.

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