Centre for the Mind

The Centre for the Mind is a joint venture of two of Australia's premier universities, the Australian National University and the University of Sydney. The Centre invests in daring research on fundamental topics about the brain and mind. It stage manages spectacular initiatives which challenge and inspire and it acts as a nexus for the great minds of the world.

Professor Allan Snyder

The Centre for the Mind is a joint venture of the Australian National University and the University of Sydney. News Limited provided the foundation sponsorship. Nelson Mandela is the Millennium Fellow and Dr Oliver Sacks the Foundation Fellow.

The Centre is a recognised brand internationally, known by millions of people around the globe. The Centre is mentored through its board and advisory council by Australia's most influential and creative minds, including Phillip Adams, Nobel Prize laureate Peter Doherty and film director/producer Baz Luhrmann. It has received worldwide media focus, including dedicated television and radio profiles; documentaries by the British BBC; the American ABC; the Tokyo Broadcasting System; and the Australian ABC; as well as extended features in the New York Times; the Times of London; many other leading international media publications, and the esteemed scientific journals Nature and Science.

Research

The Centre's research focuses on creativity and human potential with a view to benefiting society.

The Centre's research on revealing the mind's hidden skills using transcranial magnetic stimulation was published in the Journal of Integrative Neuroscience. This work was reported in major features by the New York Times, The Times of London, Der Spiegel, The Australian Magazine, ABCTV USA, Discovery (NBC TV Documentary), and many others. A new area of research was initiated about nonconscious problem solving (the "let me sleep on it" phenomenon) with a paper submitted to Psychological Science. In addition, the Centre formulated an information theoretic approach to evaluating a person's creativity – the Creativity Quotient, also submitted for publication.

Finally, the Centre just completed a study on the nonconscious evaluation of angry faces using transcranial magnetic stimulation. A new laboratory is presently being set up for brain/mind investigations jointly with the Research School of Biological Sciences.

Nexus for Great Minds

Professor Elkhonon Goldberg, acclaimed neuropsychologist and Director, Institute of Neuropsychology and Cognitive Performance in New York, presented lectures at the University of Sydney and for the Australian National University at the National Museum of Australia as part of the ANU Toyota lecture series. His subject was the neuropsychology of decision making.

Highlights

The International Spotlight was on the Centre when in April the Centre's research was singled out in the BBC's prestigious 2003 Reith lectures presented by the eminent neuroscientist Professor V. Ramachandran.

The Centre's Director, Professor Allan Snyder, was awarded the Australian Centenary medal "for outstanding research in the physical and biological fields" in May.

Spectacular Initiatives

Sir Richard Branson was awarded the 2003 Centre for the Mind medal and presented an address on Creativity and Championship. The event captured the attention of the national media including ABC TV.

Major Addresses

Professor Snyder delivered the:

1. Dinner address "Enhanced Creativity: A Challenge to Neuroscience", at the Pfizer Awards Dinner held at the Museum of Contemporary Art, Sydney;

2. Annual Dinner address: "Creativity: An Act of Rebellion!" to the Association of Professors of the University of Sydney held at the University of Sydney;

3. Key note address at the Sir Richard Branson Distinguished Fellow medal presentation at the University of Sydney.

Outreach and Media

The Centre received world-wide media attention, including worldwide and Australian television features, extended features in popular press and documentaries devoted to the Centre's research.

Examples include:

- Discovery Channel documentary entitled "Savants" on the Centre's research on creativity and nonconscious skills was

produced by a team from the American TV network NBC and has been screened internationally;

- "Savant for a Day", feature article in The New York Times Magazine. Allan Snyder claims that he can turn on a person's inner Rain Man, and then turn it off again, with the flick of a switch;
- The Tokyo Broadcast System TV Network filmed a documentary on exploring the extraordinary skill of savants as part of their "Human Brain and Love" life science special;
- ABC Newsmagazine, USA. Interview with Barbara Walters – feature on Centre for the Mind's breakthrough research;
- ABC, Australia. New Dimensions with George Negus – Championship;
- The Times, London – feature article focussing on the Centre's research on creativity and nonconscious skills;
- National Geographic Magazine is preparing a feature

Staff (ANU and University of Sydney)

Professor and Head of Centre
Professor Allan Snyder FRS FAA FTSE

Professor and Associate Director
Professor (Douglas) John Mitchell

Postdoctoral Fellows
Dr Elaine Mulcahy (until May)
Dr Martin Brüne (until October)
Dr Maria Hennessy

Visiting Fellows
Dr Elaine Mulcahy (until May)
Professor Terry Bossomaier

Research Associates
Homi Bahramali (from July)

Research Assistants
Dr Angela Yates
Rowena Henery (until August)
Toby Hawker (from October)

Project Officers
Ms Jackie Bailey (until October)
Mr John McDougall (from November)

Web Development, Event Management, Sydney Administration
Ms Natasja Worsely (until October)
Ms Antigone Foster

Departmental Administrators
Mrs Amanda Greaves (until April)
Ms Maria Gidis (from May)

Publications

Brüne, M. and Mulcahy, E.

Exaptation, Cooptation and the Evolution of Human Cognition

Evolution and Cognition 9 (2003) 25-30

Snyder, A., Mulcahy, E.*, Taylor, J.L.*, Mitchell, D.J., Sachdev, P.* and Gandevia, S.C.*

Savant-like Skills Exposed in Normal People by Suppressing the Left Fronto-temporal Lobe

Journal of Integrative Neuroscience 2 (2003) 149-158

Professor Robert L. Dewar

Centre for Complex Systems

Theoretical Studies: From the Cosmos to Quantum Systems, from Statistical Mechanics to Biophysics.
http://wwwrsphysse.anu.edu.au/ccs/

The Centre for Complex Systems plays a major role in drawing together the disparate complex systems science components of the National Institute of Physical Science (NIPS) at the Australian National University.

The aims of the Centre are:

- to provide a framework for bringing researchers together and stimulating interaction and synergy between them;
- to promote innovative, interdisciplinary research through seminars and topical workshops;
- to foster graduate education and research through summer schools.

The CCS continues the outreach activities of its predecessor, the Centre for Theoretical Physics, while fostering innovative application of the powerful tools of modern theoretical physics and applied mathematics to problems ranging from the physical to the biological sciences, and even beyond to complex systems with a social dimension. A key feature in these systems is a large number of individual units interacting collectively and the emphasis is on the emergent behaviour beyond the elementary laws of interaction. The unifying theoretical and mathematical tools include statistical mechanics, many body theory and nonlinear dynamics, as well as numerical simulation.

Administrative support is provided by the Department of Theoretical Physics, Research School of Physical Sciences and Engineering.

The formation of the CCS in late 2001 came at a very opportune time because of the declaration in January 2002 of complex/ intelligent systems as an ARC Priority Area and the CSIRO's designation of complex systems as an emerging science area, coupled with funding to set up a CSIRO Centre for Complex Systems Science headquartered in Canberra.

An ARC Special Research Initiative Network Seed-funding application titled

Energetically Open Systems Research Network Study, submitted as an initiative of the Centre for Complex Systems, was successful in attracting $10,000 for 2003-2004.

2003 International Physics Summer School

The main event of 2003 was the 16th Canberra International Physics Summer School: *The New Cosmology*, 3-14 February 2003.

Convener: Dr Matthew Colless
Committee: Dr M. Colless, Professor M. Dopita and Professor R. Dewar

The Summer School was sponsored by the Department of Theoretical Physics, RSPhysSE, the Research School of Astronomy and Astrophysics, and the Department of Physics, Faculty of Science. The lectures will be published by World Scientific, continuing the *Canberra International Physics Summer Schools* series. Despite the disastrous bushfires in January, which destroyed much of the Mount Stromlo Observatory, the Summer School proceeded as planned and was well attended, with 51 participants attending over the two-week period. Forty graduate-level one-hour lectures were presented by 13 excellent lecturers from Australia and overseas: John Ellis (CERN, Switzerland), Guinevere Kauffmann (MPIA, Germany), Charles Lineweaver (UNSW), Rachel Webster (Melbourne), Frank Briggs (ANU/ATNF), Geoff Bicknell, Matthew Colless, Michael Dopita, Ken Freeman, John Norris, Bruce Peterson, Brian Schmidt and Susan Scott (ANU).

CCS Seminars

- Dr Ken Wessen, *Simulating Human Evolution*
- Dr Markus Brede, *Random Evolution of Idiotypic Networks: Dynamics and Architecture*
- Dr Gabriele Bammer, *What can Complexity Science offer the new specialisation of Integration and Implementation Sciences?*

2004 Summer School

Preparations are well in hand for the 17th Canberra International Physics Summer School, *Photons@Work*: Australian Synchrotron Summer School, 27 January —5 February 2004.

Director: Professor Robert L. Dewar, FAA
Deputy Director: Professor Murray T. Batchelor
Chair of Board: Professor Denis Evans, FAA

The Cooperative Research Centre for Functional Communication Surfaces

Dr Mark Knackstedt

The Cooperative Research Centre for Functional Communication Surfaces (CRC SmartPrint) began operations on 1st July 2001, following funding from the Australian Government. Principal academic partners are located in Chemical Engineering, Monash University, Applied Mathematics, RSPhysSE, and the CSIRO Divisions of Forestry and Forest Products and Molecular Sciences (Clayton, Victoria). Industrial partners include AMCOR Packaging (Australia) Pty Ltd, Carter Holt Harvey Tissue Pty Ltd, Norske Skog Paper Mills (Australia) Ltd, Note Printing Australia Ltd and PaperlinX Pty Ltd (Australian Paper). Total Commonwealth funding over a seven year period is ca. $14 M, to be distributed among the various research groups.

The brief of the CRC FCS is to advance Australia's printing and packaging technology and expertise, with particular emphasis on advanced papers and polymeric materials (including banknotes), smart packaging indicators, improved recycling of paper and enhancement of cardboard packaging. Unglamorous though these areas sound, they are major industries in the Western world, and even minor incremental improvements in these areas are of major benefit to consumers and producers. A number of research areas are covered by the CRC FCS partners, including extensional rheology, surface chemistry and energy, polymer rheology, colloid science, three-dimensional imaging of microstructures, and print quality analyses. The ANU node is focused on providing accurate microstructural data of relevant materials, analysing the surface physics of imbibition of, for example, inks into papers, developing accurate mechanical models and measures of mechanical properties of various printing substrates. A novel feature of our contribution is the insistence that Applied Mathematics focus on the fundamental aspects of research. This tack has been welcomed by our industrial partners, who recognise the dearth of fundamental understanding of many processes associated with printing and paper and board production. The industry remains largely empirical, despite its enormous economic importance, and the group in Applied Mathematics are ideally equipped to investigate a number of important and interesting issues from our fundamental research perspective. While the issues are industrial in motivation, a number of fascinating problems that call on our skills are being tackled. The work is experimental, theoretical and computational, in keeping with the philosophy of Applied Mathematics. Projects are making extensive use of the new X-ray CT machine, the Surface Forces Apparatus, Atomic Force Microscope and Ellipsometer.

In the second complete year of the Center, the ANU program continued work on four fundamentally based projects and a fifth, strategic project aimed at addressing specific industry problems. Here we describe highlights of research from the four fundamental projects that have commenced.

Structural Characterisation of Paper and Coatings

In this program we aim to experimentally image and characterise the morphology of paper and coatings in three dimensions. This year we have also developed three dimensional image enhancement techniques to remove blurring and distinguish material boundaries that are particularly suited to the analysis of tomographic images of two-phase materials such as paper. Image skeletonisation and generation of network equivalents of paper and coatings have also been initiated. We have utilised the Applied Mathematics' X-ray micro-CT facility along with commercial CT scanners, two-photon confocal facilities and synchrotron facilities overseas. The ability to measure the structure of paper at different resolutions has shown the resolutions needed to obtain accurate structural maps of paper and coatings in 3D. We have also continued the development of software to analyse structural, mechanical and transport properties directly from 3D digitised images of complex materials.

Dynamic Behaviour in Paper and Coatings

In this program we aim to experimentally study fluid wetting phenomena in fibre webs and porous coatings. The structure of the pore space together with local surface energy considerations are the chief determinants of fluid penetration processes. We have conducted experiments visualising the penetration of a wetting fluid into paper fibre webs. We have developed of a new dynamic method to measure fluid penetration into paper sheets using x-ray radiography. This allows for analysis of dynamics of fluid flow and penetration rates in wicking tests. The new technique has proven to be successful to study a great

variety of paper types (filter paper, unsized paper, paper towels and r&d paper samples). Currently, software for analysing the data (e.g. saturation profiles, density correlations) is developed. Previous data analysis software has been further developed. Data processing is now automated and the visualisation routines have been significantly improved. The experimental studies of vapor condensation in paper have been continued for various paper types (e.g. filter and unsized paper).

Force Measurements Applicable to Papermaking and Paper Performance

Here we aim to experimentally determine fundamental surface properties of papers and pulps and evaluate their role in paper performance. Understanding the consolidation of paper coatings is crucial for print quality.

An SEM and AFM study of paper coatings has been published in order to improve current understanding. These studies form a solid base for further work on measuring drying stresses using a new drying stress device which is currently under construction. A compressional rheology rig suitable for use with X-Ray CT has been built. Customised software has been written to control the pressure within the rig and measure the loss of fluid from the fibre cake. This will allow the consolidation of paper fibres with and without additives to be studied. The ability to image the fibre cake in 3D will reveal the structural changes that take place at different stages of consolidation. The effect of fibre treatments, fibre size, fibre morphology and a range of additives will be investigated.

Modelling the Penetration, Spreading and Flow of Fluids on Realistic Paper and Coating Morphologies

In this program we aim to develop a multiphase flow solver to accurately model in 3D, fluid penetration, spreading and flow on realistic substrates. This ambitious project is based on the need of industry for accurate models of two- and three-phase fluid flow on complex morphologies in which both viscous and capillary effects are properly accounted for. This program aims to combine experimental information on the study of fluid wetting phenomena in fibre webs and porous coatings along with realistic pore structures generated via CT imaging to develop a model for characterising dynamic flow into paper and coatings. This year, a dynamic model for wetting fluid penetration (imbibition) has been developed based on a physically realistic and mathematically rigorous treatment of the complex dynamics of wetting front displacements. Film thickening, film flow rates, pore filling by films and viscous pore penetration are all considered in the model. The evolution of a wetting fluid into a porous material and the competition between pore filling and film flow arise as a natural consequence of the model. The effect of fluid flow rate on the dynamics of imbibition are studied over *6 orders of magnitude* in Capillary Number (ratio of viscous to capillary forces). The displacement patterns simulated are consistent with fluid penetration experiments.

Program Manager: Dr Mark Knackstedt

Program Leaders: Dr Vince Craig and Dr Tim Senden

Research, technical and administrative support for the ANU program is undertaken by staff and students mainly from the Department of Applied Mathematics.

The Australian Photonics Cooperative Research Centre (Canberra Division)

Professor John Love

Research, technical and administrative support for the ANU group is undertaken by staff and students from the Laser Physics Centre, Applied Photonics Group, Non-linear Physics Group, Plasma Research Laboratory and Department of Electronic Materials Engineering.

The Australian Photonics Cooperative Research Centre (APCRC) is in its twelfth year of operation. It is an unincorporated collaborative venture established in 1992 under the Commonwealth Government's Cooperative Research Centre scheme. The following organisations are partners in the APCRC: The Australian National University, the Universities of Melbourne, Sydney, and New South Wales, RMIT University, TAFE NSW, ABB Transmission and Distribution Ltd, AOFR Pty Ltd, Allen and Buckeridge Pty Ltd, the Australian Electrical and Electronic Manufacturers Association, Australian Photonics Pty Ltd, BAE Systems Australia Limited, Bishop Innovation Pty Ltd, CEOS Pty Ltd, Coherent Scientific Pty Ltd, The Department of Defense (DSTO), Ericsson Australia Pty Ltd (resigned in 2003), Micreo Ltd, Future Fibre Technologies Pty Ltd, JDS Uniphase Pty Ltd (resigned in 2003), Macquarie Photonics Pty Ltd, Nextrom OY, Nufern Inc, Redfern Photonics Pty Ltd, Telstra Corporation Ltd, Transgrid, Tenix Systems Pty Ltd, and VPISystems Inc.

The objectives of the APCRC include:

- enhancing the Centre's status as Australia's centre of excellence in photonics with an internationally recognised, commercially relevant basic, strategic and applied research program that integrates research strengths from enabling technologies to applications;
- improving the international competitiveness of Australian industry through transfer of photonic technology through a commercialisation program that enables established firms to access technology and skills while creating new firms, through access to technology, markets, skills and finance;
- promoting photonics through education and training at the tertiary, technical and high-schools and colleges levels and through outreach to the broader community.

In response to the industry downturn in 2000, and recognising the APCRC's mission to help develop a strong photonics industry for Australia, the Centre has moved its research focus to areas where it is believed that the best near-term commercial opportunities will emerge. It is clear that the market is no longer able to sustain the high cost of the development of discrete photonic components, and lower cost processes and increased integration and advanced manufacturing techniques provide the means for future cost reductions. As a precursor, the Centre's research program was restructured during the latter part of the year to refocus on four key projects that draw on the capabilities of the Canberra, Melbourne and Sydney nodes and those within the CRC companies. The new projects include:

- Systems to monitor/manage impairments in high-capacity communication links;
- Fibre to the premises (FTTX);
- Wavelength division multiplexed transponder systems;
- Distributed sensor systems.

The Canberra division is directly involved in the first three projects. As a result, there has been some refocusing of the projects within the existing research programs covering photonic integrated circuits, novel photonic components and photonic information processing to support activities required for the new projects.

Research Program

The interaction with Redfern Polymer Optics (RPO) on campus is through a collaborative project that has focussed on the design of novel photonic devices for fabrication in RPO's proprietary inorganic polymer glass (IPG) material. The work included investigation of segmented structures to provide for enhanced coupling between standard optical fibres and high index contrast waveguides; the design of waveband splitters; and work on reactive ion etching of RPO's IPG materials.

The APCRC-supported work on the HARE PECVD system in the Plasma Research Laboratory continued. During this year the HARE team have made significant progress towards the deposition and characterisation of hydrogen-free germanosilicate waveguide

films, and have fabricated rib-shaped waveguide structures to allow optical losses and single-mode operation to be determined over a wide wavelength range.

Another film-forming technology supported by the APCRC is the ultra-fast pulsed laser process. The laser deposition installation has been updated with the addition of a laser amplifier.

High peak-power pulses of up to 40 W are achievable in the second harmonic (532 nm). The laser installation will be used for the deposition of various high optical quality non-linear optical films and magneto-optic films for waveguide applications in photonics, for the formation of nanoclusters, as well as for research into combinatorial material synthesis in a laser-produced plume.

ANU researchers from the Applied Photonics Group continue to make strong contributions in modelling and theory of both linear and non-linear photonic devices.

A wide range of modelling work has been undertaken supporting the design of novel fibre or planar waveguide structures required for the research and commercialisation activities of the APCRC as well as in support of outside industry.

The APCRC contributes to work on silicon photonics in the Department of Electronic Materials Engineering; non-linear optical materials in the Laser Physics Centre; 4-D holography for photonic signal processing in the Laser Physics Centre; spatial solitons and other non-linear guided waves in the Applied Photonics Group, the Optical Sciences Centre and the Laser Physics Centre.

ANU researchers have also been involved in a number of CRC-linked contracts with external organisations, including ADC Australia, Nufern Inc, Ericsson Australia, RPO, DSTO and ABB. During the year two new patents have been filed, making a total of fourteen patents from ANU APCRC research currently under prosecution.

The Canberra Division received $914,480 of Commonwealth and $91,448 of ANU funding in 2002/2003. The budget for 2003/2004 is set at $681,818 Commonwealth and $68,182 ANU funding.

Education & Training

– the Photonics Institute

The School has strong links with the Photonics Institute Pty Ltd, a subsidiary company of the Australian Photonics CRC that is responsible for the education, training and outreach activities of the Centre. The Institute is supported by Commonwealth and ACT Government grants and by the APCRC, and its offices are located on the Bruce Campus of the Canberra Institute of Technology (CIT). Professor John Love is the Centre's Director of Education and Training, Dr Andrew Stevenson is the General Manager and Mr Satis Arnold from Tekhne Pty Ltd is a consultant to the Institute focusing on government links.

The Photonics Institute continues to develop a package of undergraduate teaching modules and supporting resources for the higher-education sector.

These modules cover various aspects of guided wave photonics, technology and devices and are being designed to suit direct "face-to-face" as well as distance education modes. The Institute is also advising and collaborating with the Canberra Institute of Technology to develop curricula and courses for an Advanced Diploma of Photonics Technology, and for the VET sector nationally.

The Institute engages in a variety of activities to promote photonics awareness and skills in the academic and industrial arenas and in the general community.

Within Australia these activities range from supporting development of curricula and laboratory experiments for high schools, through to community events, presentations to teachers, careers advisers and students, specialised industry courses and conferences.

Activities that involve the Institute and the School in photonics include the annual Australian Conference on Optical Fibre Technology (ACOFT), the ACT Siemens Science and Engineering Experience, the Korea-Australia and the Singapore-Australia Photonics Schools, the National Science Teachers Summer School, the ACT Science Teachers Workshop, the National Science Festival, the National Youth Science Forum and the CIT Advanced Diploma in Photonics Technology. Postgraduate students from the School have been closely involved in several of these institute outreach activities with local schools and the general community, including hands-on photonics workshops for secondary school students, outreach visits to schools to promote photonics courses, and the Photonics Institute display at the ActewAGL Amazing World of Science during the National Science Festival.

Group Head (ANU); Director of Research; Director of Australian Photonics Pty Ltd: Professor Barry Luther-Davies (until September)

Group Head (ANU); Director of Education and Training; Key Researcher: Professor John Love (from October)