

# *Technology Foresight & the University Sector*

Prepared by CIRCA Group Europe Ltd., Dublin  
for  
Conference Heads of Irish Universities



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Conference of Heads of Irish Universities



The Conference of Heads of Irish Universities commissioned The CIRCA Group Europe Ltd to prepare this report in order to assemble information on the research capacity of the Irish Universities which was not previously available. The report was prepared with the cooperation of the universities as a constructive contribution to deliberations on the implementation of the Governments' Technology Foresight Initiative.

*Dr T N Mitchell*  
*Chairman*  
*Conference of Heads of Irish Universities*

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## Executive Summary

Foresight was correct in identifying lack of scale in the research efforts in biotechnology and ICT research as the major obstacle to establishing world-class capabilities in Ireland.

The universities therefore welcome the Government decision to invest £560m, and the recent announcement of the Foundation. This move will bring about a quantum change in investment levels in research in these two key sectors and signal internationally the strong commitment to research in Ireland.

The universities, together with the other research institutions, have the capacity to implement much of the Technology Foresight proposals. Universities will fully co-operate with the Foundation and they welcome the announcement, made at the launch of the Foundation, that an initial peer based competitive call for proposals will shortly be made. They are satisfied that the establishment of separate research institutes, as originally signalled, is neither a necessary nor a cost-effective option. Additional facilities may well be needed. Where this is the case however, they should be very closely linked to the university sector.

To assert, as the ICT Panel has, that "current structures are incapable of developing teams with world class scale or expertise" ignores the achievements of many world class researchers in ICT in the university system and the strength of the NMRC in particular. The Biotechnology Panel, in fact, urged the development of the existing research infrastructure. The universities would support this approach. In fact, the concept of stand-alone institutes was not endorsed by any of the other seven Foresight Panels.

This report sets out to establish the facts about the existing research activities and resources in Ireland and it shows that there are already more than 60 university-based, research-active institutes and centres in biotechnology and ICT in the university sector alone. Some are well established, others are new and growing. Many have been greatly assisted by the recent HEA PRTLII Programme, which will add some £220m additional support to research infrastructure in the third level sector. All have considerable potential, if funding is continued. Many of the Principal Investigators involved are world class and there is evidence to show this. In addition, other research capabilities exist outside the university sector in these two technologies. Medical research is a particular example and also food science.

Universities are opposed to the a priori establishment of any new physical facilities or infrastructure for biotechnology or ICT research, which is not based on a needs and capability assessment. They will co-operate fully with the Foundation in the conduct of such a needs and capability assessment.

The universities have never stated a preference, as has been alleged, that Foresight projects be located only in university colleges. On the contrary, the universities appreciate well the research capabilities which exist elsewhere in the system and will continue to collaborate with institutions such as Teagasc, the Medical Schools, the HRB and others.

Universities would welcome Foundation laboratories on university campuses where there is a demonstrated need for them and would facilitate them. However, in relation to the issue of structures, the NMRC arrangement at UCC may indicate a productive way forward. This arrangement provides autonomy and visibility for the Centre, while retaining strong university connections. The universities are convinced that this type of arrangement, or something similar, would provide the strongest incentives for attracting the best international research talent to Irish institutions.

Universities will also want to be satisfied about any new research laboratories and their operations in order to be able to extend academic supervision and accreditation arrangements to them.

It is recommended that the universities as a priority should work together to identify key niche areas of research in ICTs and biotechnology and to develop further strategies for providing the critical mass of researchers necessary to ensure world-class excellence in these areas.

It is also recommended that the universities, via CHIU and HEA, should move immediately to establish the basis for a common platform for the university sector for a research information and management system, which will deliver consistent, uniform and timely monitoring and management information on Foresight funded programmes, for the sector as a whole.

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## Technology Foresight and The University Sector

[Note: The treatment of university sector capabilities in this paper is not intended to be comprehensive. The aim is simply to provide exemplars of university capabilities and facilities in ICT and biotechnology, mainly identifiable centres or institutes, as distinct from whole Departments or Schools - some with well established reputations and some new and rapidly growing potential - rather than attempt comprehensiveness.]

### 1. THE CONTEXT

Foresight offers £560 million over seven years for research programmes in biotechnology and in information and communications technologies (ICT). Some 500 to 600 top quality researchers will be required for these programmes.

The stakeholders want to create highly visible, world class research capabilities, which will support the growth of knowledge intensive industry in Ireland.

Among the objectives of Foresight, the following appear to be the significant ones:

- production and employment in Ireland of world class research scientists and engineers.
- attraction and retention in Ireland of the research component of high technology knowledge intensive and research active foreign industry.
- creation of high technology spinoff companies and new technology based firms (NTBFs) in biotechnology and ICT.
- repositioning of Irish industry (indigenous and foreign) higher up the value chain.

Over the period of the National Plan (2000-06) more than £2bn will be available from domestic sources for research support. Funding sources include HEA/Dept of Education and Science (DES), Dept of Enterprise, Trade and Employment (DETE)/Enterprise Ireland, the Health Research Board, the proposed Foundation, and a new Research Council for Humanities & Social Sciences, in addition to the EU Framework Programme, Community Structural Funds and other international sources. The prospects for research in third level institutions in Ireland have never seemed better, after decades of underfunding.

The institutional structures required to implement Foresight funding are currently the subject of debate. Universities offer tradition, diversity and broadly based multidisciplinary, as well as a seamless connection to skills development. Foundation laboratories have been suggested for their specialisation, focus, visibility and a fresh approach.

Needless to remark, scale and visibility are of secondary importance to quality in world research rankings. The best signals that Ireland can provide to the international community, business and scientific, regarding its commitment to science can be based only on quality.

World class, research-led universities can provide this quality and are certainly achievable in Ireland, with funding on the scale now envisaged. A focussed and supportive approach by Foresight can help to rapidly advance this objective, at least for the two areas of bio and ICT.

This paper shows the presence of individual world quality Principal Investigators (PIs) in many niches in the university system. Apart from a few however, most do not have the required scale of operation or depth of support services. Significant scale can be achieved by harnessing the new mood of inter-institutional co-operation within the third level sector, which is developing rapidly, under the impetus of new HEA funding policies. Witness the Atlantic Alliance between UCC, UL and UCG and the proposals to establish an Institute of Environmental Studies spread across the three campuses and incorporating over 50 national and international projects, or the Dublin Molecular Medicine Research Centre, as a joint venture between UCD, TCD and St. James Hospital.

## These are exciting developments.

The university system has also the capability to develop strong international alliances. Some examples from the UK demonstrate the scope of these.

### GLOBAL NETWORKING AND DYNAMIC UNIVERSITY STRUCTURES

Higher education can use global alliances to secure new dimensions in diversity and in multidisciplinary. Cambridge and MIT have linked up in an £85m deal. Leeds, Sheffield, Southampton and York universities are linking up with four research led US universities, San Diego, Penn State, Washington and Wisconsin-Madison to form the Worldwide Universities Network. They will pool research and teaching, providing mutual access to libraries, research databases, seminars and lectures. The UK proposes to establish an e-university at the cost of £120m for first two years.

### The multi-disciplinary research base of universities

The diverse and multidisciplinary research base available in the university sector offers the strongest prospects for underpinning knowledge-based development, producing the top level manpower required to drive it and attracting high quality foreign investment. This is the US model. It has served the most research-intensive economy in the world very well. It is the one that US companies appreciate and are most familiar with. With the right funding policies, Ireland has an opportunity to replicate this model, albeit on a scale appropriate to its own needs.

### THE MULTI-DISCIPLINARY RESEARCH BASE UNIVERSITIES

UCC's strengths in the integrative sciences such as molecular biology, as applied in biochemistry, physiology and microbiology underpins Food and Health Science, and the mathematical and physical sciences underpin Engineering and Microelectronics. An essential part of UCC's research strategy is to support these and other integrative sciences, so as to span departmental and faculty boundaries and to encourage individual and collaborative research on that basis. The holistic and integrated approach to create a critical mass of world-class researchers is best seen in the establishment of Research Institutes and Centres at UCC, which include the multi-disciplinary and inter-faculty National Microelectronics Research Centre, the National Food Biotechnology Centre, the Coastal Zone Institute, The Biosciences Institute and the new development of the Environment Research Institute.

Specific examples include molecular analysis of selected probiotic bacterial strains involving Medicine, Microbiology, Molecular Biology and Food Science and Technology, nutritional modulation of physiological functions related to chronic disease involving Nutrition, Toxicology and Medicine, in food safety and toxicology involving Microbiology, Molecular Biology, Nutrition, Toxicology, Analytical Chemistry and Medicine. Strong collaboration also between NMRC and the Departments of Biochemistry, Chemistry, Microbiology, Food Science, Physics, Mathematics and Applied Mathematics.

A proposal has been developed to establish the Dublin Molecular Medicine Centre as a strategic alliance between TCD (Molecular Medicine Institute) and UCD (Conway Institute of Biomolecular and Biomedical Research). This development will signpost Dublin as a major International centre for biomedical research and will be a further stimulus for the pharmaceutical Industry to invest in research in the Dublin area.

Currently, many leading international research institutes collaborate actively with the Signal and Systems Research Group at NUI Maynooth. These include: The Center for Systems Science, Yale University; The Department of Electrical Engineering, University of Strathclyde, Glasgow; The Department of Computing Science, University of Glasgow, Glasgow; The Department of Engineering Cybernetics, Norwegian University of Science and Technology, Norway; The Instiut Josef Stefan, Slovenia- The Biomedical Systems Laboratory, University of New South Wales, Australia; The Department of Electrical Engineering, Technical University, Praha, Czech Republic; The Department of Physics, University of Kent, Canterbury, UK- The Isle Optics, Taunton, UK; The Faculty of Informatics, University of Ulster, Jordanstown, Northern Ireland; Space Technology Ireland, Ltd.

At DCU the new National Centre for Plasma Science & Technology (NCPST) includes researchers from the Schools of Physical Sciences, Chemical Sciences, Mathematical Sciences, Electronic Engineering, Mechanical and Manufacturing Engineering and from the Institute of Technology at Tallaght. In addition to fundamental research on plasmas the NCPST will develop plasma deposition and processing of electronic and industrial materials. Plasma processing is key to the success of microelectronic manufacturing processes.

## Funding

The research capacity of the Irish University system is being underpinned by an increasing range of funding sources now being developed, as indicated in Table 1. It is crucial that any new source of funding for research build on existing strengths and be complementary to existing funding arrangements. The policy objectives of developing world-class research-led universities in Ireland can be significantly advanced by a co-ordinated approach from the variety of funding sources now becoming available. Clarification of funding policies for research (for example, as below) would also help. It is proposed that Foresight funding will complement other sources of funds and support existing activities. The thrust of each funding source however, the 'division of labour', should be clear in order to avoid double funding. Therefore, some consideration to the rationalisation of funding mechanisms and sources, existing and proposed, would be worthwhile.

Table 1. Funding types and sources

FUNDING TYPE	SOURCE
Research 'floor' funding	<i>Basically, the HEA bloc grant. Enabling all teaching staff to undertake a level of research to support their teaching duties.</i>
Project funding	<i>Competitive project support, for example via the present Humanities and Social Science Research Council and the EU.</i>
Institutional funding	<i>Competitive support to institutions to help achievement of critical mass in strategically selected areas of institutional competence e.g. the PRTL 1999/2000 of HEA</i>
Targeted funding	<i>Top down support for selected national priorities and sectors. Foresight's ICT and bio are examples and HRB.</i>
Industrial contract research	<i>Research contracts from industry</i>

## 2. A UNIVERSITY-WIDE PERSPECTIVE

The purpose of this paper is to outline the general university position in respect of Foresight funding and the strong capacity of the universities to undertake the level of research required to meet the Foresight objectives. The content is based on recent discussions with the Presidents/Provost, Vice Presidents/Deans of Research and Principal Investigators on campus in the two areas of Foresight, viz. ICT and biotechnology.

The aim is to sketch a university-wide perspective on what is being proposed under Foresight, to outline processes which universities would wish to see adopted for implementing Foresight and to provide the Foundation stakeholders with a good overview of the main capabilities which the universities can offer in each of the two areas.

The processes which will be developed to implement the Foresight programmes and funding will be especially important for the universities. The issues for consideration include how competitive processes are to be organised, the role of peer review, the selection of niche areas, and the modalities to be employed, the relations between dedicated Foresight establishments (if any) and the universities, the opportunities for inter-institutional collaboration etc. These are matters for the Board of the Foundation, nonetheless the universities as major players will have a legitimate point of view to express and to be considered. Inputs by the universities on such matters will help to influence the shape of resource allocation processes and procedures.

Much of the effort to date has been to question the notion of independent research institutes. The more positive approach to be developed now by the university sector, following the announcement of the Foundation, will be to demonstrate, in concrete terms, what the universities themselves can offer in these areas and how they propose to respond to the requirements of Foresight.

Policy makers and programme managers responsible for Foresight need reassurance from the university sector that the universities understand the requirements of Foresight and have the capability and willingness to respond. And also that they possess the necessary project management capabilities.

The paper provides some hard 'exemplars' and indicators which demonstrate the current university capabilities to meet the requirements of Foresight, to be able to utilise effectively the funding which will be available and to guarantee visibility, transparency and accountability in the management of these funds. In other words, how the universities will shape up to the Foresight criteria.

A comprehensive treatment of the whole university system is not attempted. Rather, only sample illustrations using specific cases and exemplars, are presented. Some represent well-established capacities and some are new and rapidly growing potentials.

The paper therefore, identifies some of the important facilities currently available in the university sector to support Foundation programmes and describes some of their achievements. It also provides some initial proposals on process, which reflect the university perspective on how the allocation of resources should proceed and on the criteria to be employed.

### 3. UNIVERSITY CAPACITY IN ICT AND BIOTECHNOLOGY

The general university position on the Foresight proposals, especially the intention to establish 'green-field' research institutes has already been well developed and communicated to the various Foresight stakeholders – the Department, EI, Forfas etc. University concerns about the establishment of stand alone research laboratories by the Foundation are therefore well understood. Several recent articles in various media have developed these concerns for public audiences.

Basically, the universities are not convinced that 'greenfield' growth of new institutions is justified or necessary, given the research facilities already available in universities and in other public sector institutions in Ireland. No evidence has been offered to support such a development. It would not provide good value for money. The universities, and the other existing research institutions, offer a more cost-effective option. It makes sense to develop existing strengths rather than dissipate scarce resources by seeking to build multiple systems.

Proposals to establish stand alone research institutes ("not uniquely associated with any existing university or third level institution, should have an independent identity and location," as proposed by the ICT Foresight Panel) are surprising. No evidence has been produced anywhere to show why this is necessary. There is no objective policy basis for it. Further, the implication that the existing infrastructure is potentially unable to deliver is unfounded and unfair to many world class performers in the university sector, in medical research establishments and hospitals and in the existing state research institutes. In the context of the present ICT / biotechnology complex at UCC, the £26m+ Conway/Elan development at UCD or the TCD capabilities in computer science, biotechnology and genetics, to mention just a few, it is truly astonishing.

The basis for the assertion that stand alone institutions are necessary or that they offer better prospects for achieving the goals of Foresight is not clear either. There is no data or analysis to support this position. On the contrary, there is sufficient evidence to show that the universities, in association with other third level institutions, the Institutes of Technology, and the country's existing research institutes, can with appropriate funding policies, deliver the Foresight requirements. Any new facilities that may be required must be closely linked to the university sector.

The ICT Panel, which alone recommended stand alone institutes, asserted "...current structures are incapable of developing teams with 'world class' scale or expertise". A proposition of such importance, presented without evidence, must raise some doubts about the quality of the underlying analysis. There would seem to be no policy basis for it, no corroboration from any of the seven other Panels, nor any endorsement of the proposal to be found in the ICSTI Overview Report. In fact, the Biotechnology Panel seems to clearly call for development of the existing infrastructure, rather than establishing new facilities. Without the evidence, it remains a matter of speculation as to what may have motivated the ICT Panel to make such a recommendation and DETE to adopt it, for both sectors.

#### THE SMURFIT INSTITUTE OF GENETICS, TCD

The Institute at TCD, is under the direction of Prof. David McConnell, and has a new purpose built facility for genetic research with state of the art equipment for molecular genetic research including an animal barrier facility for housing of specific pathogen free transgenic and knockout mice and state of the art computer facilities for bioinformatics.

Principal Investigators at the Institute have outstanding achievements in research including the first linkage to ADRP gene rhodopsin, generated the first rhodopsin knockout mouse and the first therapeutically relevant Ribozyme, targeting retinal genes.

The Institute is currently managing and conducting external research contracts totalling £5.6M. Blindness research at the Institute has attracted a total of more than £9m in external funding.

Novo-Nordisk, Denmark and Genencor, NL on industrial enzyme biotechnology, Interactiva Biotechnologie GmbH on biochip, bioinformatics and biocomputing, Fort Dodge Laboratories, Sligo and ApoAlert Palo Alto, California, IdentiGEN, OptiGen Technologies Ltd., Advanced Technologies, Cambridge. Three patents filed have been filed and one with BioResearch Ireland.

In 1997, six members of the Department published five papers in Nature.

## THE NATIONAL MICROELECTRONICS RESEARCH CENTRE AT UCC

Established in 1981, the Centre is the largest research institute in Ireland. It is also the largest centre for ICT research in Ireland with a total budget of €6.5m (1999), a research income of €4.4m (46% provided by industry) and a total staff of 260. €2m is provided by the Department of Trade, Enterprise and Employment. The Centre has over 100 postgraduate students and more than 50 preparing for PhD degrees and has the largest intake of postgraduate students in microelectronics in Ireland. The number of PhDs at the Centre exceeds 50. Training courses are provided for industry. The Centre also participates in a range of EU funded projects. Total research income at the Centre from EU was €3m in 1998.

In 1999, the Centre secured over €5.5m, and 36% of the total EU funding to Ireland under the 1st round of EU 5th Framework Programme awards for ICT technologies. It is an EU designated Large Scale Facility and the only European research centre to be selected to participate in the European Union ICT Advanced Research Initiatives in nanoelectronics, optical interconnect, nanoscale information devices and quantum computing.

The Centre has genuine world class credentials in microelectronic research and development, works closely with multinational companies located in Ireland and also provides assistance to indigenous small and medium sized companies. It incorporates the National Nanofabrication Facility, The European Space Agency Microelectronics Technology Support Laboratory, Optronics Ireland Research Centre and a PEI Technologies Research Centre.

The Centre works with all the major players in the industry, companies like Motorola, Intel, Cypress Semiconductor, Analog Devices, Nokia, Apple, IBM, HP, General Semiconductor, Mitsubishi, Artesyn, Bourns Electronics, EMC, Connaught Electronics, Dovatron, Vedia, Mentec, Kerry Foods and many others. The Centre is unique in Europe to be funded by Intel to perform basic research for the company.

The Centre has an Innovation Office, staffed by a Group Manager and two Commercial Managers to develop new business and promote NMRC services to industry. The Office is also responsible for protection and commercialisation of the intellectual property portfolio of the Centre.

There are more than 60 research groups in the university sector with outstanding PI's and with the potential for growth and development. One wonders what analysis of this capability led the ICT Panel to make such a sweeping assertion and such a damning assessment of current capabilities?

### Sustainability

In addition a formidable range of facilities in these two areas, in the university sector (centres, institutes and structured research groups), already have an established momentum. Foresight investment must take account of these and seek added value, before considering the creation of new facilities. In contrast the proposed new institutions have no certainty of funding beyond the period of the National Development Plan. What would happen to stand alone institutes with an "independent identity and location", as suggested by the ICT Panel? How would their continuity be guaranteed, how would their costs be covered? Would they become a drain on the available resources or be wound up when Foresight is finished? Thus far, all proposals for new institutes have avoided this important issue. Indeed, the momentum behind proposals for new institutes is surprising, given how little factual analysis is available to support the case and considering both the risks and the long lead times involved with new institutions.

Tables 2 and 3 outline some of the current facilities and institutes in existence in the university sector in each of the two areas. These cover some 60+ university-based institutes and centres in total – 26 in biotechnology and 36 in ICT.

#### PANOZ INSTITUTE AT TCD

The Panoz Institute is a multidisciplinary teaching and research unit, with 60 researchers, specialising in the pharmaceutical sciences. It is the only such academic Institute in the state and houses the School of Pharmacy. The four Departments conducting research in the building are Pharmaceutics, Pharmacology, Pharmacognosy and Pharmaceutical Chemistry. The main topics being addressed include novel drug delivery system design and evaluation, drug design (e.g. estrogen receptor modulators, MAO inhibitors) and Biotechnological aspects of medicinal plants as sources of novel bio-active molecules.

A particular research strength of the Institute is in drug delivery system design. This group applies basic physical, chemical, material biological and engineering principles to solve novel dosage form design problems and therefore has links with the Chemistry, Physics, Math, Computer Science and Biochemistry departments in College and Elan Pharmaceutical Technologies on the TCD Campus and in Athlone.

Apart from publications, recognition of research quality internationally is evident from the presence of staff members on the editorial Boards of International Journal of Pharmaceutics, Journal of Microencapsulation, and Pharmaceutical Technology Europe and representation on Scientific advisory committees of Conferences such as Pharmaceutical Technology Conference, International Symposium on Microencapsulation and European Conference on Biopharmaceutics and Pharmacokinetics, Lipid and Surfactant Dispersed Systems(Moscow), Novel Vaccine Formulations and Delivery Systems (UKICRS). Prof. Deasy is currently President of the International Microencapsulation Society.

Collaboration with industry includes clients like Elan, Antigen, Kinerton, Norton-Waterford Ltd., Wyeth Medica Ireland, Antigen Pharmaceuticals, Schering-Plough, Chanelle Veterinary Ltd., Plaistow Ltd., Sifa Ltd., Pinewood Healthcare, Helsinn Birex Pharmaceuticals Ltd., Hewlett Packard and Zeneca Pharmaceuticals. Astra Zeneca UK, Institut Biochimique SA (IBSA) Switzerland. In addition contract research and consultancy performed, on aspects of drug delivery systems, for several other pharmaceutical/Biotechnology/Medical Device Companies including Elan Helsinn Birex Pharmaceuticals, Clonmel Healthcare, Ranbaxy and SIFA in Ireland, Glaxo, Squibb, Cyanamid, Lipha, Pfizer in the UK, Hoechst in Germany, Bausch & Lomb and FMC in the USA, and Takeda and Nippon in Japan.

#### ICT- BIOTECH COMPLEX AT UCC

The ICT –BIOTECH complex at UCC has over 400 full time research staff and 50 support staff. UCC has already invested heavily in development of information, communications technologies and biotechnologies. The infrastructure available is internationally recognised as world class and researchers are of the highest international calibre. Centres of critical mass and strategic importance are located at The National Microelectronics Research Centre and The National Food Biotechnology Research Centre. Over the coming three years, UCC will invest more than £50m in peer reviewed funds in the establishment of a Biosciences Institute, an Environment Research Institute and a Humanities/Information Technology Institute.

Table 2. Some Institutes/Centres in the University Sector in Biotechnology

Institute/Centre	University	Principal Investigator(s)
National Cell and Tissue Culture Centre	DCU	Prof. Martin Clynes
National Centre for Sensor Research	DCU	Prof. Brian MacCraith
National Food Biotechnology Centre	UCC	Prof. G. Fitzgerald
Biosciences Institute	UCC	Prof. B. Harvey
Biomerit Research Unit	UCC	Prof. F. O'Gara
Cellular Physiology Research Unit	UCC	Prof. B. Harvey
Irish National Centre for Bioinformatics	TCD	Dr A. Lloyd
Smurfit Institute of Genetics	TCD	Prof. D. McConnell
Biotechnology Institute	TCD	Prof. L. O'Neill
Panoz Institute	TCD	Prof. O. Corrigan
Biochemistry	TCD	Prof. C. Williams
Moyne Institute of Preventive Medicine	TCD	Prof. C. J. Dorman
Sir Patrick Dun Research Laboratory	TCD	Prof. D. Kelleher
Institute of Bioscience and Bioengineering	UL	Prof. D. O'Beirne
Centre for Research in Industrial Biochemistry	UL	Dr T. Pembroke
Neuro-Biotechnology Research Group	TCD	Prof. R. Anwyl
Centre for Biomedical Engineering	NUIG	Prof. G. F. Imbusch
National Diagnostics Centre	NUIG	Prof. J. A. Houghton
Conway Institute Biomolecular & Biomedical Research	UCD	Prof. H. Brady
National Agricultural & Veterinary Biotech Centre	UCD	Prof. M. Boland
Research Centre, St Vincent's University Hospital	UCD	Dr C. O'Farrelly
Bioengineering Research Centre	UCD	Dr A. Carr
Food Science Centre	UCD	Prof. B. McKenna
Centre for Colloid Science & Biomaterials	UCD	Prof. K. Dawson
Institute of Bioengineering & Agroecology	NUIM	Prof. M. Downes
Institute of Immunology	NUIM	Prof. K. Mills

Table 3. Some Institutes/Centres in the University Sector in ICT

Institute/Centre	University	Principal Investigator(s)
Networks & Communications Engineering Centre (RINCE)	DCU	Prof. C. McCorkell
Vision Systems Research Group	DCU	Dr P. Whelan
Software Engineering Group	DCU	Prof. A. Moynihan
National Centre for Sensor Research	DCU	Prof. Brian MacCraith
National Centre for Plasma Science and Technology	DCU	Prof. E. T. Kennedy
National Microelectronics Research Centre	UCC	Dr G. Crean
Constraint Processing & Intelligent CAD Group	UCC	Prof. J. Bowen
Centre for Unified Computing	UCC	Dr J. Morrison
Centre for Computer Networking	UCC	Prof. C. J. Sreenan
Artificial Intelligence Group	TCD	Dr P. Cunningham
Applied Information Systems Group	TCD	Dr J. A. Redmond
Centre for Health Informatics	TCD	Prof. J. Grimson
Computational Linguistics Group	TCD	Dr C. Vogel
Computer Architecture Group	TCD	Dr B. A. Coughlan
Computer Vision and Robotics Group	TCD	Dr G. Lacey
Foundations and Methods Group	TCD	Dr M. MacAnAirchinigh
Distributed Systems Group	TCD	Dr. V. Cahill
Image Systems	TCD	Dr C. O'Sullivan
Networks and Telecommunications Group	TCD	Dr D. O'Mahony
Materials and Surface Science Institute	UL	Prof. K. Hodnett
Soft Computing and Re-engineering Group	UL	Prof. T. Cahill
Centre for Research in Communications Technology	UL	Prof. C. Burkley
The Transport Study and Research Group	TCD	Dr M. O'Mahony
Manufacturing and Materials Group	TCD	Prof. J. Morgaghan
Biomechanics Group	TCD	Prof. D. Taylor
Fluid and Vibration Group	TCD	Prof. J. Fitzpatrick
Trinity Centre for High Performance Computing	TCD	Prof. J. Sexton
Information Technology Centre	NUIG	Prof. G. Lyons
Computer Integrated Manufacturing Research Unit	NUIG	Prof. J. Browne
Cognitive & Computational Neuroscience Centre	UCD	Prof. M. Kane
Centre for Healthcare Informatics	UCD	Dr P. Felle
Smart Media Institute	UCD	Prof. M. Keane
Digital Signals Processing Group/Teltec Ireland	UCD	Prof. A. Fagan
Signals & Systems Group	NUIM	Dr J. Keating
Software Modelling Group	NUIM	Dr P. Gibson
Graphical Data Research Group	NUIM	Dr A. Winstanley

In addition to the above, very significant new facilities in biotechnology, and to a lesser extent in ICT, are being developed through the funding being provided by the HEA under PRTL1 1999 and PRTL1 2000. For example, as many as 14 major new facilities have recently been established with HEA/PRTL1 1999 in the biotechnology and ICT sectors. The 1999 HEA/PRTL1 programme provided investment in new or expanded university institutes and centres totalling an unprecedented £105m. Tables 4 & 5. The next phase of this investment programme will provide another £65m, with an emphasis on inter-institutional collaboration. By any standards these are major developments. Relative to the past they are truly seismic. One can only speculate now how the Foresight Panels would have reacted had they appreciated the scale of things to come in the university sector, or how it might have changed the perspectives of university capabilities.

Table 4. HEA Supported University Institutes/Centres in Biomedical/Biosciences 1999

Location	Institute	Recurrent £'s	Capital £'s	Total £'s	Post Grads	Post Docs
UCD	Conway Biomedical & Biomolecular	1.6m	19.4m	21.0m	-	15
NUIG	Centre for Biomedical Engineering	2.6m	12.9m	15.5m	25	14
RCSI	Biopharmaceutical Institute	2.3m	6.4m	8.7m	16	12
DCU	National Centre for Sensors	1.3m	7.3m	8.6m	44	14
TCD	Molecular & Cell Biology Institute	0.4m	-	0.4m	11	-
TCD	Neuro-degeneration Institute	0.4m	-	0.4m	8	4
NUIM	Centre for Immunology	0.9m	3.5m	4.4m	12	5
NUIM	Centre for Bioengineering &	0.9m	3.5m	4.4m	26	12
UCC	Agroecology	0.7m	9.0m	9.7m	6	5
UCC	Biosciences Institute	0.6m	-	0.6m	5	5
	Food & Health Sciences Institute					
	Totals	<b>11.7m</b>	<b>62.0m</b>	<b>73.7m</b>	<b>153</b>	<b>86</b>

Source: HEA Feb. 2000

These research facilities will offer quick-start opportunities, much quicker than new institutions.

Typically, the latter will need between five and ten years to establish, from scratch, the international research reputations, which are being sought. It is likely even that the National Plan would be almost completed before anything substantial would be evident from new institutions. In addition, their benefits might prove transitory for Ireland, if they are not well integrated into the existing institutional system for research.

From a cost point of view, there is no justification for duplication of central facilities, administrative services and research facilities such as libraries, central information and computing services, all of which it would be necessary to replicate, if stand alone research institutions are established.

Organic growth, based on exploiting the research infrastructure currently available in the university sector provides better prospects for quicker and more cost-effective utilisation of Foresight funds, and without having to trade quality for speed.

Table 5. HEA Supported University Institutes/Centres in ICT 1999

Location	Institute	Recurrent £'s	Capital £'s	Total £'s	Post Grads	Post Docs
UCC	Nanoscale Science & Fabrication Facility	0.5m	9.4m	9.9m	72	36
TCD	Institute for IT & Advanced	0.4m	7.6m	8.0m	6	1
DCU	Computation					
	Research Institute for Network and	0.7m	7.5M	8.2m	40	10
DCU	Communications Engineering (RINCE)	0.8m	4.8m	5.6m	19	5
	National Centre for Plasma S&T					
	Totals	<b>2.4m</b>	<b>29.3m</b>	<b>31.7m</b>	<b>137</b>	<b>52</b>

Source: HEA Feb. 2000

#### Universities have the capacity to utilise significant additional research funding:

- UCD is investing £60m in the biosciences - the Conway Institute, the Biotechnology Centre and the Veterinary Building. The Development Plan for its 320 acre site was revised in 1998 to provide for areas for suitable private public partnerships, of which the establishment on campus of the Elan Corporate Headquarters and European Research Laboratories are significant endorsements of UCD capabilities in the biosciences.
- UCC's Campus Control and Development Plan indicates the availability of space and plans for further developments in food science, biotechnology and ICT at the UCC campus
- The Moyne Institute at TCD can accommodate a doubling of activity and can absorb at least one and possibly two additional world class research groups.
- At the present time TCD is currently operating a development programme of more than £2bn. Most of the universities are engaged in substantial investment and development programmes on foot of the £220m investment programme being provided by DES/HEA.
- The Smurfit Institute for Genetics operates from new purpose build and state of the art facilities at TCD and has scope for expansion in terms of equipment and personnel. Anything up to two fold increase in post docs and post graduate students and an expansion of research groups by three to four times the present complement, could be accommodated immediately.
- NUI Maynooth has completed a new Development Control Plan to accommodate a construction programme costing in the region of £40m over the next three years. This includes expansion capacity of up to 300% in the Biosciences facility and 200% in the ICT area. An additional 13 acres has been purchased adjacent to the North Campus for further expansion.
- TCD is constructing a new Information Technology building with accommodation for eight new research laboratories and this will be ready for occupancy in 2002. Space is not a limiting factor. The Department of Computer Science at the college is the largest department and is capable of absorbing significant new funding rapidly and has done so successfully in the past (for example, the new degree programme in communications technology with 120 students each year).
- At TCD planning permission has already been sought for a building for an Institute of Molecular Medicine and the Durkan family donation of £2.2m will leverage further funding for biotechnology research in the leukaemia area.
- UL was the first to respond to the national shortage of software graduates with a new 4,200m<sup>2</sup> building which was designed, built and commissioned in less than 18 months. Most of the buildings at UL are of recent construction and lend themselves to rapid and relatively inexpensive re-configuration. The university has a large landbank and relatively few planning problems and can readily absorb additional capital and current funding.
- TCD has recently commissioned a task force to develop a purpose built Neuroscience Research Institute.
- UL is currently developing a £9m IT Centre Building, with 50% of the funding coming from the HEA IT Skills Initiative. The building is at an advanced stage of construction and is scheduled for completion by September 2000. This will provide 41,000 sq. ft. of state-of-the-art facilities for ICT teaching and research (see picture). About 35% of the physical space of the building is dedicated to advanced research.
- Capital developments totalling £173m are currently underway on the DCU campus – almost 65% provided from private sources.
- In the recent Cycle 1 phase of the HEA PRTL the formation of three major research centres was supported by the award of 22.5M Punts to DCU. The new National Centre for Sensors (NCSR) and Plasma Science & Technology (NCPST) and the new research institute RINCE (Research Institute for Network and Communications Engineering) will lead to a doubling in the number of young researchers in these areas over the next three years. They will be housed in a new building scheduled for completion in late 2001.
- UCD has just completed a new Computer Science building costing £3.5M that now caters to a postgraduate population of 72 MSc and PhD students, the department having increased its postgraduate numbers by 100% in each of the last two years.

#### THE CONWAY INSTITUTE AT UCD

Including post-doctoral fellows, postgraduate researchers and technicians the total number of researchers in the Conway Institute of Biomolecular and Biomedical Research is approximately 400. The mission of the Institute is to promote knowledge, health and economic advancement through excellence in the biomolecular and biomedical sciences. The Institute adopts a holistic approach that draws on the breadth and depth of talent among UCD's Faculties of Medicine, Veterinary Medicine, Science, Agriculture and Engineering. The goals of the Institute will be realised through the establishment of a critical mass of researchers investigating biomolecules through activities which include synthesis and analysis of structure, function at the molecular, cellular and integrated organism level and the molecular mechanisms of disease.

The objectives of the Institute are:

- To increase understanding of the pathogenesis of disease, identify new therapeutic targets, and improve the treatment of common human and animal diseases;
- To provide a first-class educational environment, in which teaching is delivered by research-active academic staff, to equip its graduates for careers in the expanding knowledge-based bioindustry and healthcare sectors;
- To offer partnership through collaborative research, strategic alliance and consultancy to the chemical, pharmaceutical, medical and healthcare professions and related industries in order to embed these industries in Ireland.
- To help meet the needs of the Irish bioindustry for the 21st Century, based on the Foresight exercise carried by The Irish Council for Science, Technology and Innovation.

Researchers have been selected for inclusion in the Conway Institute by means of a rigorous internal competition. Criteria used include track record, extramural funding (they key researchers have between them raised IEP 24.1m over the past 5 years) and publications. 60 Senior Investigators were chosen on this basis for core Senior Investigators. Funding of over £20 million has been provided through competitive funding schemes (HEA 1999) and fifty per cent of this is provided by private donorship.

The Institute has stimulated the recent decision of the Elan Pharmaceutical Corporation to establish their corporate headquarters and a major new Research Institute on the UCD campus. It is significant that the Conway Institute was seen as a major factor in attracting Elan to establish a major Research Institute in UCD and in Ireland. To date the pharmaceutical industry in Ireland has been mainly based on manufacturing with some process development but very little research especially in the area of drug discovery.

#### SENSOR FOR SENSOR RESEARCH AT DCU

The National Centre for Sensor Research (NCSR), which was established in October 1999, comprises of over 80 researchers, from both DCU and the institute of Technology Tallaght. The multi-disciplinary research team of biologists, physicists and chemists is based on 8 clusters of expertise, covering Biosensors, Bioreceptors, Micro-systems and Instrumentation. The Programme ranges from fundamental studies of molecular recognition through the commercialisation of applications-driven devices. It includes projects in biosensors, novel instrumentation, and DNA chip/biochip technology, all of which were identified as strategic technologies by the Technology Foresight Health and Life Sciences panel. Much of the work of the centre straddles both ICT and Biotechnology, combining, for example, biomedical sensing with communication and intelligent software to produce portable technologies for advanced healthcare. Centre members hold a large number of patents and a number of these have led to commercial devices. For example, in 1999 Siemens launched a colour and turbidity sensor developed by DCU researchers. The NCR includes scientists who are world leaders in their respective areas.

#### NATIONAL CELL AND TISSUE CULTURE CENTRE, DCU

This is a biotechnology research centre with purpose built laboratories and is internationally recognised for its work in animal cell biotechnology. Its work is close to the themes of the Technology Foresight study – gene therapy, antisense therapy, functional genomics, tissue engineering, gene function in disease apoptosis and development biology.

It has generated more than £11m in external research contract funding and has published in all major cancer research journals as well as producing many standard reference texts for researchers in these fields.

It operates international training courses on behalf of the Federation of European Biochemical Societies with scientists from more than 17 countries attending.

It has developed four new products from its own research programmes and commercialised these via BioResearch Ireland, with cumulative sales of £0.5m. The Centre also developed the ANA kit and other processes for the production of diagnostic kits for Biotrin Ltd. The Centre collaborates with many biotechnology companies in Ireland – Organon (generating 16 jobs on campus and a further 20 at Organon, Novartis, Schering-Plough, Trinity Biotech, MedNova and others and internationally with Berlex Biosciences San Francisco, Roche Molecular Biologicals, Germany and Diosynth, NL. Diosynth has invested more than £4m in the development of facilities at the Centre, which now has full European Medicines Evaluation Agency approval for production of protein.

#### Development through competition

The universities believe there must be strict adherence to the commitment to competitive, peer-based processes in determining the allocation of Foresight funding. The universities would not support any pre-assignment, or ring fencing of the available funding. All processes should be competitive, following such well established models as exist in the US, or for example, as operated by the UK Wellcome Trust. Calls for proposals should be international and open to national and national/international alliances.

#### Universities and the Technology Foresight Foundation

The universities support the establishment of an independent 'Foundation' acting in an 'honest broker' role, and for the management, monitoring and evaluation of the impact of Foresight funds. The Foundation should be transparently autonomous and free from outside interference in relation to its decision making on the allocation of Foresight funds. Universities are strongly of the view that the Foundation should not be both a funder and performer of research. If it were to play both roles, a level playing field for all, could not be assured. Perceptions of preferential treatment for Foundation Laboratories would be inevitable. Ring fencing some of the funds for its own laboratories would be a de facto distortion of the competitive ethos on which the whole project is founded. Nor would it be good for quality. It would be divisive and damaging to the authority and independence of the Foundation. Ultimately, it would undermine the credibility of the decisions of the Foundation, weakening it in the eyes of the scientific community.

#### Developing new research capacity

The Irish research system needs project and programmatic funding. It needs support for recurrent costs, for overheads and especially for improved research support services. Foresight can help to provide this.

Many of the excellent university research facilities are sub critical. But, these can quickly become world class with investment to increase the scale of operations. The people involved are already world class, but the scale is not. This is the issue to be addressed ahead of investment in new laboratories.

The ambition of the universities would be to establish the 'foundations' for a cumulative and self-sustaining growth process in the Irish research system. Capability retention and sustainable long term development of the research system is the objective. University environments, not the mooted 'guest-house' facilities for transient and visiting researchers, offer the best prospects of this.

Universities are conscious of the need to sustain the development of recent large scale capital investments in ICT and Biotechnology made possible under HEA PRTLTI. Ideally this could be supported through Programmatic funding from Foresight.

The universities have shown the imagination and the flexibility necessary to identify new areas of research and their ability to develop world class expertise in niche areas has been constrained only by lack of resources. Niche strengths have been developed where it has been possible to access funding. Universities will be happy to work with the Foundation in identifying new niche areas. The level of development of current capabilities cannot be the only guide to future directions in research. The universities therefore, welcome the opportunity to work with other research establishments in Ireland and abroad in implementing Foundation programmes.

It must be clearly demonstrated that the existing infrastructure is unable to meet the objectives of supporting strategic research of world-class standards in the key areas of ICT and biotechnology, before new research infrastructure is considered. If on the basis of needs analysis new laboratories are deemed necessary, universities would welcome the establishment of Foundation laboratories on campus. They would facilitate them and develop strong organic linkages, shared staffing arrangements and provide rights of access to common facilities to them to ensure the benefits of the research and teaching interface, offered only by university institutions. The success of the NMRC at UCC as a quasi - independent research institute with some 265 staff, is an example of how this can be achieved.

Stand-alone new laboratories would be divisive and damaging, create unnecessary competition, reduce co-operation and result in higher prices and costs. They would be a waste of public monies and be damaging to the third level research system, especially to the universities. The Max Planck institutes in Germany have undermined university research in German universities to the extent that Germany is losing post doctoral researchers to leading US universities.

Better to utilise existing capacity, inside and outside the universities, to the limits, growing it organically to fill gaps, as these are identified. This approach will be more cost-effective and provide a faster start-up for the programme.

### Building capability through collaboration

The existing research infrastructure in the country should be central in the Foresight approach. The universities have never stated a preference that projects be located only in colleges, or be confined to the third level sector. On the contrary, as is evident from current practice, the universities will continue to work closely with the existing research infrastructure, research institutes like Teagasc etc., and with funding bodies, HRB etc., in the achievement of Foresight objectives. For example, the universities are well aware of the importance of academic and clinical linkages in health research and of the connections between experimental and theoretical work in agriculture and food research.

#### UNIVERSITIES, HOSPITALS AND RESEARCH INSTITUTES COLLABORATE

- Four universities (UCC, UCD, NUIG and TCD) have combined with Teagasc (Moorepark and Dunsinea) and BioResearch Ireland to develop an agreed collaborative programme of research in agri-food biotechnology.
- A meat research cluster, combining universities and Teagasc recently developed a joint submission to Framework Programme V for 10m Euros funding. More than half of the publications from Teagasc at Moorepark in the past five years on food technology are co-authored with UCC researchers.
- During 1999, the National Diagnostics Centre at NUIG established a Strategic Alliance in Animal Biotechnology involving the National Diagnostics Centre, NUI, Galway and Teagasc, Athenry. This alliance will lead to the development of a range of new inter disciplinary research programmes and to the establishment of a dedicated National Animal Biotechnology Centre.
- The Department of Computer Science at TCD collaborates with DCU (computation linguistics, foundation methods, IT in education), with UCD (computation linguistics and IT in education), with NUIM (foundation methods), with DIT, St James Hospital and Tallaght Hospital (health informatics)

Research links between hospitals and third level institutions have always been essential in biomedical research. The universities have always encouraged and facilitated these linkages. The university position is not self-serving. Rather it is that all available capabilities must be fully exploited by Foresight before embarking on the construction of new 'greenfield' facilities. If the need arises at all for these, they must be residual and not alternative to existing capabilities.

#### ESTABLISHED NETWORKS AND LINKAGES AT NUIM

The Immunology Group can exploit its well established connections with:

- Hospitals: St James's, St Vincent's, Blanchardstown
- University Departments: Biochemistry, Genetics, Microbiology and Physiology, (Trinity College Dublin);
- Virology and veterinary Medicine, (University College Dublin), Biotechnology (Dublin City University)
- Industry: Elan Corporation, BioResearch Ireland, SmithKline Beecham, Pasteur Merieux Connaught, Chiron Corporation
- Irish Equine Centre, Kill Co. Kildare

Universities also offer the opportunity for collaboration with Institutes of Technology and other research institutes and for the stimulation of the wider national research system. The universities would welcome opportunities to strengthen research linkages with the Institutes of Technology, linkages which are already developing rapidly under the stimulus of the HEA PRTL I initiative.

#### Examples of collaboration include:

- The Mid West Research Foundation incorporates NUIG, Sligo Institute of Technology, Galway Mayo Institute of Technology, University of Limerick and Athlone Institute of Technology.
- Dublin City University and the Institute of Technology, Tallaght have forged a strategic research link under the HEA PRTL Programme.

#### THE ATLANTIC ALLIANCE –UCC, NUIG AND UL

The Memorandum of Understanding to establish the Atlantic Alliance was made by the Presidents of University College Cork, National University of Ireland, Galway and the University of Limerick on 20th October, 1997. This is a consortium of three universities with the objective of developing structures which enable them to develop an integrated infrastructure. A Statement of Planned Collaboration has been agreed and launched with a commitment to extensive research collaboration within the Alliance. A joint organisational and management structure has been established, along with a common financial framework and a programme of collaborative projects, reflecting the complementary strengths of the participating institutions, has been developed. A joint collaborative research submission to the HEA PRTL I Cycle 2 has emerged from the Alliance, involving the participation of more than 30 different institutions, including the three universities and practically all of the institutes of Technology. The Alliance represents a fundamental reconfiguration of inter-institutional collaboration in the university sector and offers excellent prospects for creating both scale and scope in shared research efforts between the three participating universities in the future.

Also important in facilitating collaboration is the HEAnet network, funded by the universities and the HEA, which provides a broadband infrastructure between all universities, Institutes of Technology and other research establishments in Ireland for access to Web based data bases and resources and the sharing of information. HEAnet provides high quality connectivity to the world's leading advanced education and research networks. The development of Internet2, with which HEAnet is associated, will position Ireland's research and education institutions along with the blue riband US universities, at the leading edge of worldwide internet activity.

Universities may also seek to involve world class international universities and research groups in the execution of Foresight programmes. Whereas universities have the capability to do this, it would be difficult if not impossible for a start up institution to do it. These international alliances will be important in attracting more top quality researchers to ultimately locate in Ireland.

In any event, the 'stand-alone' concept is not a viable one, without close links to the universities. Even the long standing Max Planck institutes are now being told to develop these linkages. Research reputations have to be earned, they cannot be bought, no matter what the scale of resources on offer.

### University research activity in the two sectors is very well connected internationally

- NMRC at UCC has an extensive network of European and US clients. In recognition of its international profile the Centre will host the 2000 IEEE VLSI Packaging Workshop and the European Solid State Devices Research Conference in Cork.
- The National Cell and Tissue Culture Centre at DCU operates international training programmes which are competitively allocated (1994, 1996, 1999 and 2001 recently awarded to the Centre), for the Federation of European Biochemical Societies.
- All research groups in the Institute of Genetics at TCD have extensive international collaborations. Three highlights are the EU sponsored collaborations to sequence the complete genomes of Yeast, *B. subtilis* and Arabidopsis. Each of these consortia had more than 30 laboratories involved from the EU, USA and Japan. Each project also led to a publication in Nature.
- The Department of Computer Science at TCD is working with over 30 other universities and research institutes in Europe and elsewhere in the world and participates in a number of formal networks, including RENOIR in software requirements engineering, Maths Pour Tous for the teaching of mathematics, CaberNet in distributed systems, European Computer Driving License, (members of the Department played a central role in the establishment of the ECDL, not just in Ireland but throughout Europe), Socrates networks for promoting student and staff mobility.
- The National Cell and Tissue Culture Centre at DCU has collaborated for over 3 years with NUI Cork on the synthesis of new inhibitors for multidrug-resistance, with St Vincents's Hospital and with NUI Maynooth on yeast-cell interactions and with universities and research centres in Milan, Amsterdam, Budapest, Spain and Germany.
- NMRC and the Cork Institute of Technology collaborate on characterisation of nanoscale materials and nanostructures and with TCD, the Hitachi labs in Japan, Texas Instruments and Oxford University.
- The National Centre for Plasma Science & Technology at DCU has been invited to participate in TEPLACON (Technological Plasma Consortium), a network involving industry with the Universities of Glasgow, Strathclyde, St Andrews and the Queen's University of Belfast.
- At DCU, the Internet Protocols and Multimedia Systems Research Groups have collaborated over the past number of years with over 50 Universities Research Institutions and companies in Europe and the United States. This collaboration resulted from 9 EU Telecommunications Research projects of which 5 were managed by Teltec-DCU.
- UCD's Department of Computer Science is a member of two EU Research Networks of Excellence in Machine Learning and Multi-media, along with having collaborations with several leading US universities (e.g., Carnegie Mellon University, Princeton University and University of Washington).

The potential of the universities to establish and to participate in such international alliances in the execution of Foundation programmes offers the possibility of building long term bridgeheads for the attraction of high quality personnel to work in Irish institutions.

#### University emphasis on developing research talent

University emphasis would be first and foremost on developing talented people, programmes and facilities, before buildings. Buildings and infrastructure are only the beginning. What matters in the long run is a support structure that delivers adequate funding for equipment and running costs year in year out. Up till now these have been grossly inadequate throughout the scientific community in Ireland. It would be a major blow now, just as world class facilities are being established in the universities, if additional capacity were to be established which would compete for the limited pool of talented post-graduates and post-doctoral researchers.

Technology push models, reminiscent of the failed policies of the '60s in Ireland (and elsewhere), without the gain from education and training, will fail again. Proximity matters. Close proximity between research and teaching - this seamless process offered by research universities - will embed the results of research, education and training in high quality manpower and carry it into the enterprise sector.

Post graduates for the knowledge based economy must be trained to international 'best in class' standards. High quality basic research provides an environment for this and there is no other way to get such exposure for new graduates. These two are inseparable. The universities assert that research is fundamental to good teaching. The cross fertilisation of this unique relationship is based on concepts of proximity and multidisciplinary. Concepts based on the separate development of research and teaching are inappropriate for Ireland.

Ireland must not follow the mistaken French model, which separates teaching from research. The productivity of French science, as compared to the USA or UK, which traditionally carry out most of their research within the universities, is not a persuasive advertisement for their model.

There is a real benefit to students from being educated in an atmosphere of research. Multidisciplinarity is key. The seamless connection with teaching adds the value.

The priority for Ireland is the quality of human resources. The universities offer this potential. Stand-alone laboratories cannot. Investment in people and talent are the touchstones and the basis for knowledge growth and transfer. Investment in new buildings comes second.

## 4. UNIVERSITY ACCESS TO HUMAN RESOURCES

### O'REILLY INSTITUTE FOR COMMUNICATIONS AND ADVANCED TECHNOLOGY AT TCD

The Institute was established in the 1980's with private funds. It houses the rapidly growing Computer Science Department and other IT related areas. The Computer Science Department is the oldest and now the largest such department in the country with approx. 50 high level principal investigators and covering 12 themes, 100 research students and is currently in the process of a major expansion.

The institute generates more than £1.5m per annum in competitive research funding, and has produced remarkable successful spinoffs such as Iona Technologies (distributed object technology), X Communications (multimedia systems), MV Technologies (machine vision), lunet, now EsatNet and more recently Telekinesys in physical animation. The Institute is a member of the European Research Consortium for Informatics and Mathematics (ECRIM) which brings together all the major European research facilities in computer science. The institute has published 14 books including a best seller in amazon.com and holds editorship of a number of special issues of international journals and several best paper awards.

The acquisition of parallel computing power in conjunction with QUB now provides the College's best researchers with the most advanced computation facilities. Recently the College has added 10,000 m2 new space for a new Institute of Information Technology and Advanced Computation. After 15 years of planning, these two Institutes, together containing more than 60 principal investigators, represent a very strong critical mass of high quality research talent in information and communications technologies on the campus.

The proven most efficient and economical structure of research teams is one comprising postgraduate students, postdoctoral researchers and principal investigators, a mix not readily available within independent research institutes. The most critical challenge for Ireland in building a world-class capability in research as envisaged in the Technology Foresight reports, is to increase the supply of quality human resources required. This will mean above all training of increased numbers of researchers to the highest standards and attracting top-class researchers to Ireland.

The new demands will be considerable. Estimates on the likely effects of Foresight on the annual demand for post doctoral researchers and for PhD students are shown in Table 6. The numbers are the total requirements in each year.

**Table 6. Annual need for post docs and PhD students**

Category	2000	2001	2002	2003	2004	2005
Post Docs	205	205	205	350	490	705
PhD students	205	205	205	350	490	705
Totals	<b>410</b>	<b>410</b>	<b>410</b>	<b>700</b>	<b>980</b>	<b>1,410</b>

*Source: Draft 2nd report of the Expert Group on Skills Needs*

Proposals for any new research facilities to be developed under Technology Foresight should as a basic criterion be required to provide for the training and accreditation of researchers which meet the highest standards. Universities are uniquely placed to accredit research work for qualification purposes and to integrate research developments into the teaching and training of future researchers.

The difficulties of attracting world quality researchers to locate in Ireland will be formidable and must not be underestimated. Arguably, this will be the biggest single challenge for Foresight. Getting quality at this level into the Irish universities will be difficult enough. Getting them to locate in 'greenfield' institutes with no research pedigree, may be impossible. Funding is important, but will not of itself be sufficient. The locational preferences of committed high quality researchers are much more subtle and will not be satisfied simply by throwing money at them. Universities offer the support of a multi-disciplinary academic environment in which to work and longer term career prospect in research, issues of crucial concern to top-class researchers which stand alone institutes cannot provide for.

Universities already have a substantial pool of world-class researchers. Universities also have the capacity to recruit more from abroad who are graduates of Irish universities, who have worked on earlier international teams (Framework Programme teams etc) and who are part of the wider university networks. Universities also have an established research pedigree, which will be required to attract the rising research stars (young, about 30 to 35 years). University environments, and the advantages that they offer over 'greenfield' institutes, will more easily attract young new blood.

Irish Universities are first in Europe in the number of awards made under Marie Curie Host Development Fellowships. This could not happen if the universities did not deliver on contracts in FP4, or were unable to show that Irish Universities can train PhDs at the highest level in Europe and offer an advanced research environment for foreign EU post-docs to work and advance their careers.

#### Universities have the best prospects of attracting top-flight researchers

- UCD has hired more than 200 staff in the past decade using well established networks and recruitment strategies. The university has also recruited three Directors of Research Institutes in the last year, including Conway and the new Institute of Criminology. The College uses its Newsletter 'UCD Connections' to keep in touch with graduates. The university does not envisage difficulties in recruiting the best people, provided the packages offered are attractive.
- The Moyne Institute at TCD has access to the mailing lists of the American Society for Microbiology, the Biochemical Society, the Society for General Microbiology, email listings for the journal Molecular Microbiology, in addition to research contacts with group leaders world wide who will fit the profile or required personnel.
- Principal Investigators are generally associated or members of international research consortia which provide contact with young researchers seeking research appointments. At UCC several are members of the Marie Curie Fellowships and the Wellcome Trust New Blood Fellows.
- Universities can grow their own research personnel.
- Bioinformatics, a particular strength of the Smurfit Institute of Genetics for the past 15 years. has produced a large number of undergraduates who have gone on to have outstanding careers abroad. The Centre has maintained links with them through current research programs, and with appropriate salaries and research support, many could be persuaded to return. However that this is an area of biotechnology where trained people can command huge salaries in the private sector. Therefore remuneration for these people and research support would have to be very significant to attract quality people.
- The Smurfit Institute for Genetics is aware immediately of at least five highly successful graduates who may be interested in returning to form research groups at the college.
- UL will host both the world conference on software engineering and the European conference on catalysis, both of which will provide opportunities for sourcing new research personnel.
- The National food Biotechnology Centre at UCC has contacts with a large number of Biotechnologists located within Ireland and abroad. It is confident that given the right circumstances (salary, work environment, support for research) these highly qualified individuals would grasp the opportunity to perform leading edge research in a dynamic and open environment. In addition, there is also available a cohort of technically qualified people who would be in a position to support the more highly qualified postdoctoral scientists. These individuals are currently sourced from graduating classes in the Sciences and Food Sciences.
- TCD has successfully recruited 19 new academic members of staff in the past two years. While difficulties are being experienced in the ICT area, because of competition from industry this is being counter-balanced by a significant increase in the number of students from abroad at TCD. On the basis of a conservative 3 post-graduate research students per academic staff member, the Department has the capacity to absorb at least 165 postgraduate students. The addition of experienced Post-doctoral research fellows would allow this figure to be increased. There are also close links with a number of European universities under Socrates and Erasmus programmes in ICT and the college is therefore in a position to attract good quality postgraduates.

- Access to high quality personnel relates to visibility in terms of publications, collaborations and effective web-sites. In addition, there is a network of ex-graduates and ex-post-doctoral researchers, many of whom are in top quality research institutes abroad and who maintain contact with occupants. A specific example from the Biotechnology Institute of TCD was the 20 applications since December, over half from overseas, for a post advertised on the web.
- Worldwide, neuroscience is one of the largest areas of research in biotechnology. Consequently, there is large pool of researchers internationally, many of whom are interested and willing to come to Ireland and in particular, TCD which has a very high profile. Many Irish graduates already work in this discipline and would welcome the opportunity to return, if proper facilities and conditions are available.
- The Conway post-doctoral fellowship scheme at UCD has stimulated new contacts across disciplines and has attracted more than 100 post-doc applicants.
- TCD and UCD are collaborating on the development of a 'shared equity' purchase model, following the experiences of Cambridge University, for the provision of housing for top level researchers, in an effort to combat the high housing costs in and around the Dublin area. UCD has also accepted a proposal to build a further 600 places on campus from a private developer, with an emphasis on post graduates and post doctorals and will include a number of apartments for visiting and newly appointed faculty.

## 5. THE GOALS OF FORESIGHT

The basic aim of Foresight investment is to assist the repositioning of industry higher up the economic value chain. This will be done by supporting selected technologies which are key to long term sectoral and national development.

### Key Concept

An overall long-term developmental perspective informs the Foresight initiative as the ICTSI Technology Foresight report states "the concept of sustainability runs through the whole Technology Foresight process". The definition for sustainable development used in the report is 'developments which meet the needs of the present generation without compromising the ability of future generations to meet their own needs'.

Fundamental to the ultimate success of the Foresight initiative is the sustainability of the country's research infrastructure in terms of its capability to train and produce an adequate supply of top quality researchers to meet future needs. Contribution to sustainability must be a key requirement of all projects seeking Foresight funding.

### Proposed Principles

Crucially, Foresight investment must signal internationally that Ireland is becoming a high quality research location, and a credible option for mobile research-based foreign investment.

To meet these objectives, and taking account of the stated Foresight position on sustainability as understood by the universities, the following principles are proposed to guide Foresight investment policies in achieving its objectives.

Table 7. Proposed Foresight Principles

Principle	Definition
<b>Quality</b>	The standards of Foresight funded activity must be unequivocally world class, as determined by competitive, peer-based assessment processes.
<b>Critical mass</b>	The scale of investments must match international standards in the sectors supported for a critical mass of personnel and facilities.
<b>Visibility</b>	Projects must have the potential to offer high international visibility and provide the opportunity for Foresight 'branding', for use in international marketing and promotion.
<b>Flexibility</b>	Arrangements must be flexible and be capable of being changed or shut down, without long term financing obligations for government.
<b>Relevance</b>	Longer term, investments should offer the potential for commercial opportunities, for spinoffs, new technology-based start-ups, technology transfer and the attraction of knowledge based foreign investment.
<b>Transparency</b>	Proposers must offer fully transparency management, accounting, monitoring and reporting processes.
<b>Partnership</b>	As a general consideration, there should be opportunities for co-operative partnership arrangements, engaging, where appropriate, government, universities and industry.

These are suggested as general principles and not necessarily as specific criteria for the assessment of individual projects, which will primarily be concerned with research quality.

Considering these principles, the universities can offer:

#### World Class Research Quality

The basic aim of current policies for university research is to establish the Irish universities as world class research universities. This is an important objective for Ireland and is consistent with current national development objectives. Significant steps towards this goal are being made with the current round of DES/HEA funding.

It is important to maintain this momentum, to speed it up, not to slow it down or undermine it. Initiatives which strip universities of research talent would jeopardise it. Competition with private industry for research personnel is already very strong, especially in the ICT sector. Co-operation between public institutions will be required to compete effectively in a very tight labour market for top end personnel.

Under HEA 2000 this advance will continue with major emphasis on inter-institutional collaboration.

Foresight funding, allied with continuation of HEA support for strategic development, can together put the Irish universities at a world level in selected niche areas, provided the complementarities between these funding sources are fully developed.

The standing of the Irish universities in internationally competitive research fora is well known, especially in the EU Framework Programme.

#### UCC PARTICIPATION IN EU COMPETITIVE PROGRAMMES

UCC's peer-reviewed research income exceeds £75m for the latest five years. £19.0m was secured in 1997/98, which represents almost a quarter of UCC's total budget. Research funding shows a consistent growth over the past decade with a recent annual growth rate of 30%. The £21M research income won by UCC under the Fourth Framework Programme represents 32% of the total obtained by the entire Irish Higher Education sector and 16% of the total for Ireland. So far in the first 9 months since its inception UCC researchers have secured £10.5 M from the EU Fifth Framework Programme. UCC researchers have been successful in securing research grants from the most competitive of international peer-reviewed funding agencies.

World class research performance has already been demonstrated for the university sector as a whole (CIRCA Report 1996). Citation levels for the sector as a whole were shown to be at or somewhat above world citation levels. The universities are the only institutions capable of offering sustainability of this standard, mainly because of their broadly based and multidisciplinary capabilities.

The only possibility for non-university institutions to offer this advantage is by linking with university systems and benefiting from the diverse capabilities of research universities. All the international trends are in this direction. Linkages to universities are key. Unlinked to universities, in the long term they don't work. The heavily criticised and largely ineffective JRC laboratories of the EU are a prime example of top flight research laboratories without linkages to university systems.

There are many international exemplars of inter-institutional linkages which work, the Fraunhofer in Germany and the example of the top flight U.S. universities, for example, Stanford, Caltec, MIT, the US Land Grant Colleges with their close association of agricultural research and university teaching, the Karolinska in Sweden and Pasteur in France and many others. There are also false models, inappropriate for Ireland, for example the Max Planck Society in Germany, or Weizmann in Israel, which should not be replicated here.

It is virtually certain that FDI models in intellectual space are doomed to failure unless the linkages to indigenous sources of research are well established.

- Under the EU Fourth Framework Programme 1994-'98, UCD won £4.6m in competitive international funding for ICT (£1.1m) and biosciences (£3.5m). In the first round of the 5th Framework Programme, NMRC at UCC has secured more than £5.5m in research funding for ICT research.
- The neuro-biotechnology group of researchers (6 researchers) at TCD, between them have produced ten publications in Nature and several hundred publications in the top peer reviewed international journals. Major breakthroughs include their discovery of the role of novel target proteins and lipid products in neural communication and plasticity. Their work has greatly increased the understanding of mechanisms of brain damage and has allowed the development of new approaches to neuronal repair.
- The National Cell and Tissue Culture Centre at DCU has produced reference works on cancer resistance and cell culture and has published in all the leading cancer research journals.
- Many of the scientists at the National Food Biotechnology Research Centre at UCC are recognised as leaders in their fields. In the past five years, two of the three Royal Irish Academy Silver Medal Awards for Excellence in Research in Microbiology were won by Centre affiliated scientists. At the 6th International Symposium on Lactic Acid Bacteria (Veldhoven, The Netherlands, September 1999), Centre scientists represented three of the 15 major presentations; this points to the world ranking held by the Centre for research on lactic acid bacteria. The Centre has just received (Feb. 2000) an EU Marie Curie Host Development Fellowship to develop expertise in genomics and proteomics of Bifidobacterium. This award was based on its track record of achievement in research on fundamental and applied studies of lactic acid bacteria. The new activity with Bifidobacterium is being promoted in collaboration with the new BioSciences initiative in UCC.
- The work of the software group in the Physics Department of TCD, under Prof. Denis Weaire, has been repeatedly recognised by invitations to give major presentations at international conferences in Europe, the US and Japan. The latest of these is the International Conference on Theoretical and Applied Mechanics, which is a regular landmark conference of IUTAM, held this year in Chicago. The computational simulations undertaken by his group have been strongly featured in most of the leading international science magazines, and covered by the US National Science Foundation in its magazine "Connections". The international standard of this research has been recognised by election to the Academia Europaea and to the Royal Society, and many invitations to evaluate or review science programmes abroad (UK, Portugal, Brazil, European Commission, Australia). The research has always been networked with European scientists, has recently been funded by Shell (Amsterdam), and is to be incorporated in research plans for the International Space Station.
- J M D Coey is the most cited physicist in Ireland, with 450 refereed publications, 15 patents and three books. He is among the top ten scientists in his field worldwide. Honours include an honorary doctorate from the Institut National Polytechnique de Grenoble and the 1997 Charles Chree prize and medal of the Institute of Physics, London. In 1998/9 he delivered eleven keynote talks at international meetings in Europe, the US and Asia, including the Keynote Address at the European Conference for Magnetic Materials for Applications in Zaragoza and an invited talk at the APS Centennial meeting in Atlanta. Founded the company Magnetic Solutions Ltd in 1994, now a successful business providing unique permanent magnet systems for research and individual users. Collaborated closely with leading European industrial laboratories in the Materials and IT areas since 1985 in a series of EC framework-funded research programmes. Coordinated the pioneering 'Concerted European Action on Magnets' 1985-95 a group of 80 industrial and academic labs.
- Almost 60% of refereed publications in the elite international journals by immunology, bioengineering and agroecology researchers at NUI Maynooth, have citation rates which are above the world average.
- NUI Maynooth is rated 5th in Europe and 16th in the world in Apoptosis research by the Institute of Scientific Information in 1996. Immunology publications over the period 1990-1998 from NUI Maynooth cited at four times the world average. The 39th Graves lecture and Medal sponsored by the Royal Academy of Medicine in Ireland 1999. Prof. Kingston Mills.
- Staff members at UCD Department of Computer Science have won the highest international awards for their research from international bodies and at the leading conferences in the ICT field, including ES99 (1999, Cambridge, UK), HPCNC (1999, Amsterdam, The Netherlands), Japanese Society for the Promotion of Science Fellowship (1998, Tokyo, Japan), Indiana University (1998, Bloomington, USA), CSC (1996, San Diego, USA), British Telecom Fellowship (1996; UK), EWCBR96 (1996; Lausanne, Switzerland), IJCAI (1995, Montreal, Canada), ASA (1995, St. Louis, USA), Materials Research Society (1995), and ICCBR95 (Ciombra, Portugal).

## UNIVERSITIES ARE PRODUCING WORLD CLASS RESEARCH IN BOTH ICT AND BIOTECHNOLOGY

- The groundbreaking work at UL by Dr. Timothy Smyth on anti-biotic drug resistance and novel penicillins was of such world-wide appeal that it was reported at prime time on Sky News
- The Plasma Research Laboratory at DCU is the leading laboratory in the Association EURATOM-DCU which has partners in UCC and NUI-D. Funded by EURATOM, the Association has an annual budget of approximately 1M ECU. It has international collaborative projects with COMPASS, TCV, ASDEX-upgrade JET and RFX.

The already established intellectual weight of the universities in research, and the inducements which universities can offer in terms of academic advancement and career paths, will attract international researchers. Name recognition of the major Irish universities is internationally strong and provided incentive packages are competitive, Irish university environments will attract high quality international talent.

The international evidence is that it takes new institutions, no matter how well funded, at least ten years to establish an international research reputation. In fact, funding is not the major factor. Opportunities to associate with other outstanding researchers, the availability of academic career paths in an internationally respected institution, opportunities for migration to commercial development etc., all of these are now offered in the university environment.

Table 8. Indicators of research merit for Biotechnology and ICT in UCC

INDICATOR	RESEARCHER
Gold Medal, Royal Irish Academy, 1996	Prof. T. Cotter
Curran Medal in Biophysics, Yale University, 1994	Prof. B. J. Harvey
Royal Irish Academy National Commission for Microbiology Medal for excellence in research, 1995	Prof. G. Fitzgerald
The 35th Graves lecture and Medal sponsored by the Royal Academy of Medicine in Ireland, 1995	Prof. F. Shanahan
Marschall-Rhone-Poulenc sponsored international research award of the American Dairy Science Association, 1994	Prof. C. Daly
McGuckian Food Science Awards (Gold Medal), 1990	Dr P. McSweeney
Finalist Gordon Bell Price for High Performance Computing, 1997	Dr J. Greer
Distinguished Society Service Award by Instrument Society of America	Dr. L. McDonnell
IEEE Third Millennium Gold Medal 2000	Prof. G. T. Wrixon
Member of the Royal Academy of Engineering	Prof. G. T. Wrixon
Honorary Fellow, Materials Research Society of India	Dr. G. Crean
Editorial Board: Applied and Environmental Microbiology	Prof. G. Fitzgerald
Editorial Board: Microbiology	Dr D. Van Sinderen
Editorial Board: Analytical Letters	Prof. G. Guillebaud
Nature 1995, 374: 733-736	Dr. R. O'Connor
Nature 1990, 343: 562-564	Dr. T. McCarthy
Nature Genetics 1993, 5: 51-55	Dr. T. McCarthy
Proceedings of the National Academy of Sciences (in press)	Dr. T. McCarthy
European Molecular Biology Organisation Journal (EMBO)	Prof. F. O'Gara
Author / Inventor on five patents	Dr. C. Hill

## THE BIOTECHNOLOGY COMPLEX AT TCD

With funding from public and private sources, TCD established a Biotechnology Institute in 1990, the first of its kind in Ireland. The Institute is a unique facility, housing 70 industrial researchers from four companies working alongside TCD's academic researchers. Since then two new adjoining institutes have been added: The Panoz Institute of Pharmaceutical Sciences and the Smurfit Institute of Genetics. The Animal Barrier Facility, which is unique in Europe, is particularly noteworthy. The major refurbishment of the Moyne Institute of Preventive Medicine completes this cluster of institutes, amounting to some 20,000 sq. metres of new space for research and teaching. Through consolidating its relationship with St James Hospital and Tallaght Hospital, the basic clinical work at these, complements the institutes on the main campus.

Overall, more than 60 top class researchers are involved with an annual research income from competitive funding of more than £4m, partnership in 40 EU competitive projects (with leadership in 25), and over 200 publications per annum in the most prestigious international research journals.

## Critical Mass of Operations

Typically, this means at least half a million per annum for research funding and teams of about 10 high quality researchers.

### WORLD CLASS RESEARCH REQUIRES A DYNAMIC MULTIDISCIPLINARY CAPABILITY.

World class ICT and biotechnology research requires multidisciplinary capabilities, in depth. The universities can provide this.

In the case of the biotechnology, strength in depth, running through from medicine, veterinary science and agriculture, which might supply both biological materials and biological problems via biochemistry and industrial microbiology, supplying some of the solutions and methods of study and through to chemical engineering. Depth and breadth are both essential to a flexible, multi-faceted approach to problem solving, and it is difficult to see how these can be matched or replicated without establishing an institution of similar size to a university.

For research in cognitive and computational neuroscience, each of the core disciplines involved provides accounts of mental activity at different levels of granularity, based on computational models and tools from computer science. For a fundamental ability like learning, in neuroscience, it is now feasible to characterise the neural changes that occur when learning takes place and to trace the neurological pathways and regions involved. From psychology, it is possible to characterise the informational contents of learning in precise computational models that can predict behavioural outcomes. From philosophy, comes the conceptual tools for analysing and assessing the solutions to the question of the relationship between the mind and the brain built up over the last 3,000 years. And aside from the fundamental issues, software tools are required that will have practical implications for the information technology and pharmaceutical industries.

With a few exceptions, most of the existing facilities and research groups in the university sector are below internationally accepted operating levels for critical mass. On the other hand, the quality of individual principal investigators and researchers is well up to world standards. Individually, many university researchers are already world class, the difference is the level of backup and support available in Irish universities, and in the scale and intensity of operations.

The problem for the sector is in the level of research support personnel and facilities which are available. Critical mass is attainable by building on the existing foundation of excellent researchers already in the system.

The university sector offers unique advantages for rapidly building critical mass of internationally viable research teams. The pace at which universities can do this is unequalled and certainly faster than new 'greenfield' operations could hope to achieve.

## Visibility

Existing institutes on university campuses in the two sectors have already established international visibility, and offer all the opportunities required for Foresight 'branding'. The National Microelectronics Research Centre at UCC is the best example of such visibility, nationally and internationally. Others are emerging and will be accelerated by the HEA funding of capital facilities for research in 1999 and 2000, amounting to some £220m. Conway and Elan can be expected to do for UCD what NMRC has already done for UCC. Who can argue that the many institutes at TCD, Smurfit, O'Reilly etc., are not internationally visible? HEA policies and funding have moved the system significantly forward, helping the universities to invest in critical mass development in key strategic areas. Assessments proposing the establishment of stand-alone institutions need to be reconsidered in the light of these developments. The potential of modern ICTs to design a centre which would give high visibility and virtual access from a central location to Technology Foresight branded projects should be fully exploited.

## Flexibility

Many examples of structural and management flexibility already exist within the university system, for example the agreement to locate the Hitachi lab at TCD, the development of NMRC on campus at UCC and others. NMRC is an outstanding example of what can be achieved with flexible management and structures within a university campus. Universities have shown their readiness to respond positively to proposals for new flexible arrangements, either from government or from industry. For example, despite

their reservations about management arrangements, the universities co-operated fully with the authorities in implementing the PATs programme.

It is an established fact that universities offer better prospects for operational and management flexibility than other government institutions can do.

Universities are now addressing the issue of career paths, pensions, and pension transferability for post docs. Universities can establish full time research professorships and can offer honorary professorships, a feature of the successful Whitehead Institute at MIT. All faculty at the Institute have honorary professorships at the university. Universities can offer sabbaticals from teaching for academic staff and long term fellowships (5 years). Such inducements will be essential in attracting top class people.

Universities have the flexibility to provide the financial packages required to attract international researchers. Already UCD and TCD are co-operating on the development of a shared equity scheme, on the lines of similar arrangements in operation at Cambridge University, for private housing as an integral element of inducement packages for top flight international researchers. Universities can set up separate institutional structures on campus, which will have flexibility to offer enhanced salary levels.

#### RESEARCH MANAGEMENT AT NUI MAYNOOTH

NUI Maynooth has a Research Committee, established in 1998, a Research Charter, adopted in 1999, a Dean of Research and Graduate Studies, a Research Office comprising of the Dean, the Industrial Liaison Officer, the Research Grants Officer, and appropriate administrative support. The Dean of Research and Graduate Studies manages the Research Office as envisaged in The Research Charter. In this role the Dean is responsible for developing and maintaining institutional supports for the research efforts of the academic community at Maynooth. In particular the Dean facilitates NUI Maynooth researchers in the pursuit of external research funding. The Dean also works closely with the Industrial Liaison Officer and the Research Accountant in a Research Office. The Dean of Research and Graduate Studies also manages the Postgraduate Studies element of the Research Charter.

#### Relevance

#### TCD HAS DEMONSTRATED THE ABILITY OF UNIVERSITIES TO SPINOFF NEW COMPANIES:

- Iona Technologies is a billion dollar corporation by NASDAQ value. It created a high added value software platform for interoperability of computer systems, and employs over 500 people.
- Machine Vision Technology Ltd, incorporating Pentos is company with gross revenues of ten million dollars and over 100 employees, with a strong continuing investment in R&D.
- Magnetic Solutions Ltd is a research-based ex-campus company that is on the edge of lift-off by selling new Irish designed products to worldwide markets.

All were launched after years of research, building up teams and networks, and leveraging contacts with multinationals, state agencies and the campus itself.

These TCD spinoffs have attracted worldwide attention to Ireland, and are part of the favourable inward investment phenomenon of recent years. The expertise to assess and build up research-based companies still lies almost entirely within Universities.

The universities are well up to international standards in providing facilities for technology transfer and commercialisation. [CIRCA Report 1996]. Industrial liaison facilities are now available on all university campuses, intellectual property has been regularised and most universities now offer incubation for new startups and innovation centres.

The universities have recognised the limitations of technology push models and hence the move to establish commercialisation facilities. In some sectors, without these facilities, it will be difficult to attract researchers to public institutions, as in biotechnology, for example. Commercial opportunities are different between the two areas. Fast moving ICT is better. Young post docs need to feel that they will be assisted in exploiting any intellectual property that they develop, and that the facilities are available to help them to do this. These are generally now available on all university campuses. Universities have a stronger tradition and expertise in spinning off new high technology enterprise and provide the services and facilities to incubate new businesses.

## Universities have the expertise and facilities to assist the start up on technology based companies

- In 1999, two new companies (Hiberger and Alimentary Health) were established arising from activity sponsored by the NFBC at UCC. In addition to funding research that led to commercially exploitable results, the Centre (through its parent organisation, BRI) also had a major role in the formulation of the business plan, the securing of finance and the recruitment of management expertise. UCC has also recently been involved in establishing 3 campus companies, 1 biotechnology, 1 electronic and 1 software, and is currently negotiating establishment of 2 other biotechnology companies, both utilising UCC patents.
- Biotechnology research at UCC has produced 35 patents. UCC holds 28 patents in ICT technologies. TCD has produced 20 patents in biotechnology and 14 in ICT.
- UCD has produced spinoffs in ICT including WBT, AV Edge, Massana, Sephira, Parallel, BioObservation Systems, Cell Media, Talbot Technologies, Cavalier Ireland, Financial Analysis made Easy, Finalysis, Changing Worlds. In the last two to three years the (known) venture capital investment attracted by campus companies was about \$20m.
- The National Cell and Tissue Culture Centre at DCU has provided the basis for a spinoff campus company, Archport Ltd., whose new clean room facility at £3m has just been completed.
- The Constraint Processing Group at UCC has produced a spinoff company, Suntas Technologies selling constraint-based software to the CAD industry.
- The Department of Biochemistry/Biosciences Institute has produced two spinoff companies, EirX and Hyberger.
- The National Cell and Tissue Culture Centre at DCU and generated over £11m in externally funded research
- The Irish Centre for the Transfer of Advanced Computing Technology has made 90 presentations to industrial groups since April 1997, run 8 seminars to bring solutions of HPC to Irish businesses and has made contact with over 2,500 small and medium sized companies around Europe. The Centre has helped develop The Irish Association for High Performance Computing. This association works to develop high performance computing activities in Ireland, and has membership drawn from both academia and industry.
- Elan Corporation will locate its corporate headquarters and research laboratories at UCD. In conjunction with the new Conway Institute of Biomolecular and Biomedical Research (total investment £21m), this will greatly strengthen UCD's research capabilities in pharmaceutical and life sciences.
- The Ocular Genetics Unit at the Smurfit Institute for Genetics located on the campus at TCD has grown from scratch with an initial grant of £10k from a charitable organisation, to a research unit employing 20 researchers and a contract research income of £7m over the period 1986-98. Less than one quarter of this funding come from Irish Government sources. The rest came from international agencies, especially the Wellcome Trust.
- The key researchers at the Conway Institute for Biomolecular and Biomedical research in UCD have between them raised £24m for research over the past 5 years. The organisational structures of the Conway Institute include procedures for development and exploitation of intellectual property and fast tracking of discoveries to bio-industry.
- Three campus companies have been established in recent years from the work of the Smart Media Institute at UCD, including WBT Systems, one of the earliest computer-based training software companies whose Top Class software is now licensed to some 500 organisations worldwide. Another, Changing Worlds, is an Internet content personalisation specialist, whose products are currently carried by the Irish Times and via WAP-technology by Esat-Digiphone.
- TCD has incubated more than 40 companies to date. The College has purchased the IDA Enterprise Centre on Pearse Street – a five acre site which will help it to become a European Leader in the incubation of research based industries.
- Scientific Systems was established in 1995 within the Plasma Research Laboratory at DCU. The company spun off in 1998 and now has its headquarters in Dublin with headquarters in the US and Japan. Scientific Systems provides an innovative range of plasma diagnostics for direct measurement of fundamental plasma parameters.

## ELAN CORPORATE HEADQUARTERS AT UCD

The Conway Institute at UCD stimulated the recent decision of the Elan Pharmaceutical Corporation to establish their corporate headquarters and a major new Research Institute on the UCD campus. It is significant that the Conway Institute was seen as a major factor in attracting Elan to establish a major Research Institute in UCD and in Ireland. To date the pharmaceutical industry in Ireland has been mainly based on manufacturing with some process development but very little research especially in the area of drug discovery.

## Transparency

The growth of externally funded research in the university sector in recent years has resulted in universities establishing arrangements and systems for financial reporting and monitoring, in accordance with the obligations attached to such funding. Universities are now well accustomed to these disciplines. Generally, each university has its own independent system.

- The Conway Institute at UCD involves novel management and operational structures for the University. For example, the research programme at the Institute is organised into three themes, each overseen by one of the scientific coordinators. In turn, each theme has a number of strands lead by a team leader. The Institute is managed by a Director reporting to a Board of Management. The scientific focus and productivity of the Institute will be monitored on a biennial basis by an external advisory board.

The possibilities for establishing a common platform for all universities for the provision of research management information on externally funded research, is currently being reviewed by CHIU. The resources available for institutional management of research are being expanded. All universities now have Vice Presidents/Deans specifically in charge of research. Research grants and contracts offices have been established on campuses for the management of externally funded research. These facilities will need continued development in light of the demands of PRTL funding and its consequent requirements for monitoring and assessment.

The universities approach to research management and accountability has changed significantly in the past ten years, a development not widely appreciated yet. Processes and structures are evident, information systems, though still far from perfect, have improved greatly. Reporting, transparency and accountability are stronger than in the past. Strategic planning has improved on all university campuses. All universities now have strategic plans for research and are prioritising their long term research investments.

### RESEARCH MANAGEMENT AT UCC

UCC has established structures to improve the College's research support infrastructure. These include the development of a formal research support infrastructure, the appointment of a Vice President for Research Policy and Support and the development of an Office of the Vice President for Research Policy and Support staffed by the Vice President, a newly appointed Research Support Officer, an Industrial Liaison Officer, a senior executive assistant, and an executive assistant. Recently the office has further expanded by the appointment of a Projects Officer (permanent) and a Technology Transfer Manager (temporary).

The university has recently decided to put the Vice President Research position of a full time footing.

The Vice-President for Research is the senior College Officer for Research Co-ordination and Enhancement with broad responsibilities to ensure that all aspects of UCC's research support structure are integrated and operating effectively. He is a member of the Executive Management Group of the University. The Office co-ordinates activities of, and liaises with, College committees and bodies which pertain to research support and policy. The Vice-President for Research also advises the relevant College committees on strategic organisational and financing of academic developments which impinge on the College's research policy, capacity and potential

The Office is responsible for the drafting and implementation of UCC's policy and strategy on research support. Services provided include advice on funding of research, preparation of research proposals and handling the Colleges contractual involvement with industry.

Not everybody is aware of these developments and there is a residual legacy of mistrust about the universities and their capacity to manage effectively and to deliver to predetermined specifications.

Universities now have the capabilities to ring-fence external funding in institutional accounts, to provide separate financial reporting to external funders, and to present accounts to international standards of financial auditing.

### Universities have significantly improved their research management processes:

- The National Cell and Tissue Culture Centre at DCU has its own accounts office which works in liaison with the DCU Finance Office and has processed external funding totalling more than £11m. Accounting records are available to audit standards and the majority of external accounts have been the subject of external audits.
- The Conway Institute at UCD involves novel management and operational structures for the University. For example, the research programme at the Institute is organised into three themes, each overseen by one of the scientific co-ordinators. In turn, each theme has a number of strands led by a team leader. The Institute is managed by a Director who reports to a Board of Management. The scientific focus and productivity of the Institute will be monitored on a biennial basis by an External Advisory Board.
- The project management processes operated by the National Food Biotechnology Centre have been subjected to probing and detailed review processes by external (Irish and international) assessors. The results have been complimentary of the Centre in terms of the quality of research and the management structures in place.
- UCD has established (1998) a contracts database which currently holds records on 1,629 ongoing research contracts at the college. Data is inputted daily and there is quarterly reporting to the College Finance Committee. The database can show contracts by funding source/Department/faculty/Principal Investigator and keyword searching is being planned.
- All the universities now have formally documented strategic research plans and have installed specific organisational arrangements and implementation processes, including appointment of Vice Presidents/Deans of Research.

### Partnership

Universities acknowledge the importance of the partnership principle underlying the Foundation's policies.

The universities currently co-operate extensively on a wide range of programmes and initiatives with both government and industry, and will continue to do so. These partnerships have resulted in many fruitful developments.

The Universities Act permits the development of joint ventures and alliances.

The universities are well positioned to engage in international alliances with other strong universities internationally. These partnerships will be important in making fast progress.

The Atlantic Alliance (a partnership of NUIG, UCC, and UL) is a good example of new partnerships emerging within the university system for the purpose of collaboration in joint research programmes. Such arrangements overcome weaknesses in critical mass, improve efficiency in the division of labour, share expensive facilities and manpower. This particular arrangement offers opportunities to achieve the regional objectives of Foresight.

In fact, the regional disposition of university institutions offers considerable opportunities for a balanced regional approach to Foresight funding. It is important that Foresight does not add to existing regional imbalances.

Two of the Dublin universities (TCD and UCD) are currently developing a joint proposal for the establishment of The Dublin Molecular Medicine Centre.

Foresight can help to encourage further inter-institutional alliances and partnerships, a more positive direction than having small institutions, by international standards, involved in destructive internal competition.

- The UCD Development Plan for its 320 acre site was revised in 1998 and an extensive area identified for public private partnerships with the university, a major example is the recent decision by Elan to establish of its Headquarters and European Research Laboratories on the UCD campus.

## 6. A SUSTAINABLE RESEARCH SYSTEM

The Technology Foresight Report sets a vision for a knowledge driven Ireland in 2015 and identifies the need to build “a world class research capability of sufficient scale within our universities and colleges, research institutes and industry” as the principal means of realising this vision. An Irish research system that is firmly based on world-class research led universities is key to this future and is the way to ensure long term sustainability of the system.

In focusing the accelerated development of “an infrastructure which develops and transcends what is already in place” in the two key areas of ICTs and Biotechnology, policy and action must be guided by the future overall shape and structure envisaged for Ireland’s research system. Enhancing the capacity of the research system to respond rapidly to changing research priorities must be a key strategic concern and accordingly care must be taken not to build rigidities into the system. In this regard, if Technology Foresight is to be successful it must be an ongoing process working towards a vision and must not be treated as a set of programmes or institutions that become ends in themselves. Because of the unprecedented level of the funds available, decisions on their allocation will have profound effects on the research system and they therefore need to be consistent with an overall development approach for the country’s research infrastructure.

It is necessary to consider now the kind of institutional research system envisaged for Ireland for the coming decade and the institutional structures most likely to carry Ireland into a knowledge based era of economic development?

The university position is that this vision should be based on world class research universities offering a seamless connection between research and teaching. The development of world class, research-led universities in Ireland is a core objective and central to how the research system will develop. Properly directed, Foresight provides a magnificent opportunity to achieve this goal in the ICT and biotechnology sectors.

In Ireland, high quality research is performed at third level institutions and this system has served the nation exceptionally well, directly coupling advanced education with the unique training afforded by research at the intellectual frontiers. Because of this, graduates understand the fundamentals of core scientific disciplines, work on state of the art equipment, appreciate the relevance of the leading edge of technology, have the capacity for creative approaches to advanced problems and are trained in particular modes of analysis and thought. Personal experience of research in a leading university is the best teacher of these skill and capabilities.

This combination of research and teaching justifies itself not solely in the information outputs which research generates, but just as much by the contribution which it makes to the formation of skills and competencies in those exposed to it. Achieving the ambitions for a knowledge based growth will depend as much on this aspect, as on the information outputs generated from research itself. Ultimately, the skills and techniques acquired from exposure to university research enables students to accumulate and absorb such knowledge and to take them with them into industry. This mobility of knowledge embedded in trained manpower is the core of high quality technology transfer.

Research is the lifeblood of universities. Research performance enriches the teaching process, attracts high quality staff and research students, enlivens and energises the teaching environment and improves the international competitiveness of the university.

And it confers significant competitive advantages on the nation in the international market place for high quality personnel. Without knowledge intensive graduates, there will be no knowledge intensive industries. Herein lies the fundamental connection between education and the economy. The development of the Irish research system should be informed and influenced by historical factors in its evolution to date and the experience gained from this as well as by the best international evidence, especially:

**Path dependencies** - our history and institutional structures resist any tendency to convergence based on imitation. Path dependency concepts maintain diversity; respect history and cultural conditions. Our institutional evolution has now got universities at the core of the institutional research infrastructure. We aspire to the development of world class research universities. Policies and programmes already in place (PRTLII etc) are working to produce these world class centres within the university structure. This is the settled and established policy - until Foresight - which seeks to change this, reverting to a sixties model of stand alone research institutions, outside and independent of the universities.

The rush for new ready made models of what to do, imitating what appears to be successful in some other environment, only disrupts the progressive evolution and consolidation of institutional structures. Path dependency concepts in Ireland would suggest that the parachuting in of institutional structures already rejected during this evolution would not only be disruptive, but will inevitably waste time. Organic growth will provide quicker, more durable results, be more sustainable and more rooted and less risky. Free standing institutes with international reputations take decades to establish. Failure can be spectacular, for example the French 'Grand Programmes', the EU JRC institutes and many others. The universities offer a much better alternative.

**Experience and learning** - Late developer models are very relevant for Ireland. Domestic experience provides virtually no evidence to support re-establishment of failed institutional models of the 1960s. Independent institutes, unconnected to the universities have neither prospered nor succeeded. The Bush paradigm (Science: The Endless Frontier) of knowledge development has failed - autonomous and unfettered basic science and linear concepts of innovation - and have been replaced by a post-modern paradigm based on new modes of multidisciplinary knowledge production and non-linear, complex and interactive models of innovation. Universities have the flexibility and scope to offer support to such non-linear, multidisciplinary and interactive innovation processes; a flexibility beyond the potential of dedicated and focussed independent institutes. All the Irish universities now have well developed supports and facilities to assist technology transfer and commercialisation processes. Comparative analysis (CIRCA Report 1996) showed that the Irish universities were as well organised in this respect as any in Europe.

**International trends** - Research institutes which are set up to focus on specific topics are of diminishing in relevance and importance in Europe. Many are being closed down or privatised. Research agendas are being re-defined and linkages with university systems are being strengthened. There are undoubtedly good institutes. But they take 10+ years to establish and mature into world class centres. Independent free standing institutes have been extremely problematical, the JRC for example, Max Planck in Germany (recently the subject of an international review which recommended closer linkages between Max Planck institutes and the German universities).

The Max Planck Institutes (MPGs) in Germany have undermined the German university system and are now being told to develop closer linkages with the universities. Their defining characteristic of institutional autonomy and freedom to develop their own programmes, the so-called Harnack principle, has come in for criticism, on account of what is perceived as potentially fostering structural conservatism and on account of the difficulties of re-positioning these institutes to take account of completely new emerging fields of research, especially cross-disciplinary research. MPG is responding with new institutes now being located on university campuses - for example, Computer Science at Saarbrücken University, marine microbiology at the University of Bremen and nuclear physics at Dresden TH. The German experience is that the impetus for totally new areas of research very often comes from the younger members of high-level university departments, rather than from stand alone research institutes.

Institutes tend to have ageing staff with permanent tenure and recruit little new blood. In all cases, their linkages with universities are critical.

If any international model is to influence the choice of structures and processes for Foresight, it is difficult to justify looking beyond the US - the most successful scientific nation in the world today. The processes which have nurtured Stanford, Harvard, Cal Tech, MIT, Johns Hopkins, Berkeley et al and the spinoffs in Boston, Los Angeles, San Francisco etc are the exemplars that we should seek to understand and where appropriate to emulate.

A recent ten-country report by the Science Policy Research Unit at the University of Sussex (European Comparison of Public Research Systems September 1999) comments:

"Research institutions, set up to focus on specific topics, appear to be of decreasing relevance. They have been closed down or rationalised in some countries, privatised in others or had their research agendas redefined. In every country, they have strengthened their links with university research ... They tend to have ageing research staff with permanent tenure as civil servants, and recruit little "new blood". (p. 56)

This is not a university motivated report, in fact the reverse. Five of the ten members of the research team were from research institutes, including such well known international institutes as Max Planck, CNR and Ecole des Mines, making the above comments all the more remarkable.

While not exactly complimentary to some university environments either, this Report provides evidence of the growing importance of university research (the 'research university') and the diminishing role of government research institutes. Where these institutes do exist there is a growing emphasis on collaboration with universities. This is because of the importance of inter-disciplinarity and the limited potential of specialised or sector specific institutes to provide opportunities for this.

"Collaboration is demanded because even the largest research units may not have all the skills, expertise, equipment and research material demanded to carry out competitive research". (p. 63).

Universities offer the potential for both regional and sectoral distribution of the benefits of Foresight funding. Their regional distribution provides opportunities for benefits to the West and BMW regions, in particular. Their ongoing linkages with the Institutes of Technology will help to spread capacity building to these institutes.

Stand alone research institutes, which are not involved in teaching, also rule out the opportunities for interaction between research and teaching, or certainly make such interaction less satisfactory. Such links would be lost. The connections with post graduate students for research would also be lost.

Also information flows are less effective and there are fewer opportunities for sharing of expensive equipment.

Throughout the ten countries studied, there is evidence of an increasing proportion of research taking place in universities and a decreasing role for research institutes. Research in French, Spanish and UK universities has grown. Reforms in Italy in the 1980s reinforced university research. These reforms have been mirrored in Hungary. On the other hand, Danish, Italian and Norwegian research institutes have been restructured, UK research institutes have been privatised or closed down. Universities provide "... more flexibility and the capability to switch research rapidly into new areas as the need arises" (p.12).

"Several governments, struggling to find a solution to deal with the cost and inertia inherent in funding research in research institutes, regard universities as a more flexible research resource". (p. 32).

Generally, such institutes, if not being closed altogether, are being forced to strengthen their linkages with the universities. Establishing stand alone, isolated research institutes would run counter to these trends, which have also been evident in Ireland over the past 20 years. Experience shows that the autonomy of these independent institutions establishes a buffer against change and flexibility and leads to a so-called 'structural conservatism', which is change resistant.

After decades of neglect, the university research sector is now rapidly evolving, under the stimulus of recent HEA PRTL schemes (1998, 1999 and 2000). The system has responded well to these funding opportunities, demonstrating new potentials for interdisciplinarity and for inter-institutional collaboration. In respect to the latter, the developments are quite striking. A strong collaborative ethos is emerging, so much so that it is possible now to see the emergence of a research system in the university sector, rather than just seven separate institutions. This offers opportunities for more integrated and more cost effective research programmes, and for better critical mass. Critical mass is developing in well selected areas. Foresight can consolidate these new trends, moving them forward, while taking advantage of the investments already made. And crucially, Foresight offers the prospect of growing world class, research-led universities in Ireland. This should be core policy objective, and provides the best route towards a flexible and sustainable research system for the future.



## Annex 1

### SOME ADDITIONAL EXAMPLES OF EXISTING UNIVERSITY CAPABILITY

#### SIR PATRICK DUN RESEARCH LABORATORIES AT TCD

The Sir Patrick Dun Research Labs has over 70 scientists and units for Haematology Oncology Research, Histopathology Research, Immunology Research, Inflammation Research, Clinical Microbiology Research and Nutrition Research. The existing grant income is currently approximately €3 million per annum. The laboratories have dedicated facilities for Tissue Culture, molecular and cellular analysis, DNA sequencing, technology platforms for quantitative PCR analysis, Laser Microscopy, Microarrayer facilities and DNA chip reading facilities, high quality digital microscopy facilities which permit the study of individual molecules within living cells.

Research achievements include numerous international awards for studies on neural tube defect genetics/folate metabolism which have influenced public health issues, particularly relating to fortification of bread with folic acid; inflammation research has led to the successful use of Protein C in meningococcal meningitis, a clinical breakthrough of international importance based on the principles of molecular medicine; development of a DNA based test for assessing the success of allogeneic bone marrow or stem cell transplants which is now the method of choice in transplant centres worldwide, and has resulted in a number of international awards (Van der Molen Award for Leukaemia Research, European Bone Marrow Transplant Prize), the role of homocysteine in cardiovascular disease/atherosclerosis and the genetics of cardiovascular disease are areas with a high international profile; linkage mapping studies have led to the discovery of the BRCA2 gene in inherited breast cancer; recent work has culminated in the identification of a gene implicated in susceptibility to developing testicular cancer; Trinity College Dublin has had a distinguished record in the area of H pylori research. Pioneering research identified this organism as a dominant factor in ulcer recurrence and is now a "citation classic".

#### THE NEURO-BIOTECHNOLOGY GROUP AT TCD

The Group has over 30 research staff. Different types of workstations (valued several £ million) are used for the functional determination of Nervous System effects of pharmaceuticals and genetically engineered targets. These include neurochemical, neurophysiological and neuro-behavioural testing batteries enabling quantitative assessments from the single molecule level to the integrated nervous system.

The group is involved in the study of brain mechanisms in health and disease which will help in the determination of new targets for the treatment of Neurological and Psychiatric disorders and in the evaluation of the effects of novel interventions in animal models and humans. The approaches taken are multidisciplinary, from the molecular to the neuropsychological levels, and are both top-down and bottom-up.

Currently group researchers are co-ordinators or major partners in both EU Framework 4 (Biotech) and 5 (Life) programmes, receiving several million ECU. These programmes involve collaboration with over 20 top neuroscience laboratories across Europe in high quality research networks. Some of these collaborators are large Pharmaceutical companies and smaller biotechnology enterprises. In addition to this several contract research projects for industrial partners are ongoing, with major investment in personnel and running costs by the industrial partners. The group also has very close interaction with potential end-users i.e. relevant doctor and patient groups in Dublin (including St James's, Tallaght and St Patrick's hospitals). Members of the group also have funding from highly competitive international agencies such as the Wellcome Trust.

#### MOYNE INSTITUTE OF PREVENTIVE MEDICINE AT TCD

Research topics include, gene regulatory circuits in medically-important gram-negative bacteria, phase variation in bacteria, bacterial chromatin and DNA structure, site-specific recombination - structure and function of the fimbriated pilus, molecular biology of *Staphylococcus aureus*, bacterial surface proteins and protein secretion, development of novel antimicrobial agents, molecular biology of Semliki Forest Virus, viral vaccines and vaccine delivery systems, demyelination mechanisms and neuronal diseases, molecular biology of *Helicobacter pylori*, bacterial fimbriae, streptococcus equi vaccine, protozoal parasites, development of antimalarial agents, RNA splicing mechanisms, cellular responses to stress, environmental microbiology, microbiological safety legislation and standards.

The Institute is fully equipped for modern molecular microbiology: walk-in 37°C and 4°C rooms; radioactive work laboratory; growth medium preparation room with full sterilisation and decontamination services; containment facilities for work with pathogens up to Category III; photographic darkroom; darkroom for X-ray and ethidium bromide work; image analysis lab for cell biology; two large equipment rooms with cell fractionation, preparative centrifugation, and FPLC facilities; fluorescent microscopy suite; fluorimeter; containment suite for virology; tissue culture laboratory; lecture theatre with state-of-the-art audiovisual equipment; seminar room.

Research achievements of Institute personnel include Biochemistry Prize of the Royal Irish Academy, Fleming Award of the Society for General Microbiology, Microbiology Prize of the Royal Irish Academy, Personal Chair in Molecular Microbiology, Wellcome Trust Programme Grant, Wellcome Trust project grants, EU network coordinator and network members, Chair of Gordon Conference on *Staphylococcus aureus*, invited speakers at Gordon Research Conferences, organiser of Royal Society Discussion meeting on Bacterial Pathogens in vivo, only non-UK member of steering committee on UK *E. coli* and *Salmonella* genomics projects, only non-UK member of BBSRC grant assessment panels, organising committee for UK government's PRES initiative - new money to study stress responses in bacteria, and Editorial Boards of major scientific journals, Editor of journal *Microbiology*, regular invitees to international conferences and authors of 4 papers/year in high impact journals.

The Institute is currently collaborating with Max Planck Institute for Infection Biology in Berlin; Imperial College School of Medicine, London; Karolinska Institute, Stockholm; the Institute Pasteur, Paris; Microbial Pathogenesis Unit at the Université Catholique du Louvain, Brussels. Industrial collaborations with Chiron Vaccines, Siena; Inhibitex, Houston; Pharmacia, Sweden. In all cases, the collaborating partners are world-class scientists. Within Ireland, there is collaboration with Queen's University, Belfast.

#### THE COMPUTER INTEGRATED MANUFACTURING RESEARCH UNIT AT TCD

The Computer Integrated Manufacturing Research Unit takes an extended enterprises or value chain view of manufacturing. Its research efforts are concentrated on the inbound logistics chain (supply chain) and the outbound logistics systems (distribution) and indeed reverse logistics (end-of-life product dispositioning to minimize waste and maximize reuse).

There are four projects running in the e-commerce area:

- Framework V Project CHAINFEED, led by OM Partners in Belgium, this project will create a value chain optimization tool for the animal feed production industry using data made available across the value chain by Internet technology.
- Framework V Project APM, led by SINTEF, which is concerned with developing advanced performance measurement systems, which will be layered as to distributed ERP / PDM systems in a distributed manufacturing and distribution environment.
- Project SFTI, funded by the Enterprise Ireland Applied Research Grant scheme and Nortel Networks will provide a software prototype that will demonstrate the viability of enabling the reliable exchange of files over the Internet.
- Project CVFISSC, funded by Enterprise Ireland Applied Research Grant scheme and MSL Ltd., (Athlone) will provide a computer-based environment that integrates the business activities both internally and externally at MSL.

## COMPUTER SCIENCE AT TCD

There are nine research groups and two interdisciplinary centres in the Department of Computer Science at TCD. The Department currently has 47 academic staff (8 new appointments will be made in the current year), 10 full-time research, 50 full-time research students plus 30 part-time and a technical and support staff of 18.

Members of staff have won several best-paper awards at international conferences; these conferences typically have high rejection rates ranging from 50% to over 85%. Approximately 60 papers per annum are published annually in leading international journals and in the proceedings of international conferences and this figure is increasing. The department also publishes a technical report series (77 reports in 1999) which is available for download over the Internet

The annual research income of the Department is approximately £1.4 million; approximately two-thirds from EU research programmes, with the remainder being more or less equally divided between national research programmes and direct sponsorship of research by industry

5 patents have been issued over the past 5 years. OpenProlog, a freeware Prolog compiler developed in the Department, is used by over 10,000 users across the world.

There have been several very successful commercial spin-offs from the research undertaken in the Department - Iona (distributed object technology), X Communications (multimedia), MV Technology (machine vision), IEUnet (Internet service provider) and recently, Telekinesys (computer games).

In recognition of the international reputation of research, the Department has been invited to join ERCIM, as the Irish representative. ERCIM, the European Research Consortium for Informatics and Mathematics, brings together all the major European research institutes in Computer Science. Most of these institutes are government funded e.g. INRIA in France, GMD in Germany, but in some countries where there is no government funded research institute in computer science, a university or consortium of universities is invited to be the national representative in ERCIM.

The Department also maintains close links with several other companies, many of which have been established by TCD graduates. These include Broadcom, Mentec, Baltimore, Trintech, Hitachi Dublin Laboratory and New World Commerce (formally Cunav Technology). Over the past 5 years, over 40 projects have been funded directly by industry. With an average of 10 EC funded research projects per annum, the Department has strong links with universities and research institutes in Europe and throughout the world.

## CENTRE FOR HIGH PERFORMANCE COMPUTING AT TCD

The centre, established in 1998, co-ordinates activity in high performance computing in Trinity College. Its functions are to support research using high performance computing, to develop training initiatives for users of high performance computing and to identify and develop innovation in the area of high performance computing in Trinity College. The Trinity Centre was established on foot of a donation to College to allow the joint purchase of a supercomputer by Trinity College and Queen's University in Belfast.

The Trinity Centre for High Performance Computing has been actively developing a technology transfer capability. The major technology transfer activity in the past three years has been managed through ICeTACT (the Irish Centre for the Transfer of Advanced Computing Technology).

#### THE NATIONAL DIAGNOSTICS CENTRE AT NUIG

The National Diagnostics Centre (NDC) at the National University of Ireland, Galway is part of BioResearch Ireland (BRI), the Irish agency for the commercialisation of biotechnology. The Centre provides specialised services to hospitals, industries and aquaculture. Training is provided by the Centre. The Centre generated £1.5m in 1998 and maintains a staff of over 60 research personnel.

The Immunodiagnostic Group of the Centre has developed a range of assays, particularly bone marker and cardiac marker assays and these are now being marketed in kit form. The group is also collaborating with a wide range of companies on the development of rapid, automated, non-invasive diagnostic tests and is also involved in the development of immunoassays for the food industry, residue analysis, detection of pathogens in meat, fungal detection in foods and toxin detection in shellfish.

Major activities within the DNA diagnostics group are the development and application of DNA based assays for the precise and rapid detection of pathogenic microbes including bacteria and fungi. Other activities include DNA contamination detection, human gene mapping and the application of DNA diagnostics to biomedical engineering science.

The Molecular Biology Group is primarily concerned with studying fundamental aspects of gene expression and regulation. Many of these studies are carried out using model fish systems.

Priority research themes being investigated by multidisciplinary teams in the animal biotechnology (an alliance between NUIG/NDC and Teagasc), include reproductive biotechnologies, consumer-acceptable genome modification in livestock, low-cost, efficient diagnostic tests for the control of livestock diseases and technologies for the enhancement of animal welfare.

#### INFORMATION TECHNOLOGY CENTRE AT NUIG

The IT Centre was established in 1991 to develop a focus to UCG's fragmented coverage of computing. Today, the IT Centre is the largest academic discipline of the University, with 18 fulltime academic staff and 450 FTE students (of which about 120 are post-grad.), 3 full-time research professionals and 15 full-time post-graduate research students. We are currently in the middle of a major expansion phase, under commitments to the HEA, as party of the ICT Skills Initiative. This will see academic staff numbers growing to about 26-28 over the next 4 years, and student numbers expanding to about 600. The IT Centre has a young staff profile, 50% of whom have been recruited from industry. During the next 4 years, up to 10 additional academic staff will be recruited, many at senior levels, in designated specialist areas.

The main research areas include:

- Medical Informatics – medical imaging, distributed patient management
- Scientific Computing – image processing, manipulation of large data sets
- Enterprise Systems – enterprise modelling, e-commerce
- Complex Adaptive Systems – complexity theory, application of complexity to business social and economic domains, cybernetics
- Artificial Intelligence Applications – intelligent agents, genetic algorithms
- Robotics and Process Control – remote process monitoring and control, protocols
- Networks and Communications – distributed systems, network modelling and dynamic optimisation
- Media – domain modelling, graphics & image processing, distributed protocols.
- Modelling of Real World Problem Domains – discrete and continuous processes, econometric, biological processes
- IT and Organisation Design – modelling and design of socio-technical systems.
- High Performance Computing – design of massively parallel systems

#### CENTRE FOR BIOMEDICAL ENGINEERING SCIENCE AT NUIG

This Centre has been established to bring together researchers from the physical sciences, engineering, and information technology to work with university biotechnologists and clinical researchers from University College Hospital Galway to address research issues in biology and medicine. It builds on the existing research strengths and record of achievement in the areas of Biotechnology, Instrumentation, and Biomedical Engineering; in the past few years, university research workers in these areas have sustained a combined research income in excess of £3m a year.

The Centre represents a considerable investment by the University, the State, and private donors, including a £15.4m award from the HEA Programme for Research in Third Level Institutions in 1999. The Centre will be housed in a large purpose-designed building, with state-of-the-art research equipment, and will be ready for occupancy in 2001; in the meantime the Centre is in a temporary location in the new Technology Unit on the Galway campus, and a vigorous research programme has begun, using facilities in the Technology Unit and in existing departments. Researchers in other third level institutions in the western region participate in this programme.

The priority research areas are - New measuring methodologies, Cell and molecular engineering, Biomaterials, Biomechanics and Biofilms.

In the past few years, new cross faculty degree courses have been developed in Biotechnology, Biomedical Engineering, and Biomedical Science, and these courses have been endorsed by a large number of the healthcare and medical device companies that have made Ireland (and particularly the West of Ireland) their European base. Links have been established with the European Molecular Biology Laboratory in Heidelberg (EMBL) and with well-established research centres in the US. Continuing and strengthened links have been established between the university researchers and the R&D sections of the healthcare and medical device companies.

#### CENTRE FOR BIOMEDICAL ENGINEERING SCIENCE AT NUIG

The Centre was established in Summer 1999, following the award of major funding under the Programme for Research in Third-Level Institutions 1999-2001. The Centre will be housed in a large purpose-designed building, which will be ready for occupancy in mid-2001. In the meantime, the Centre is in a temporary location in the new Technology Building on the Galway campus, and a vigorous research programme has begun, using facilities in the Technology Building and in existing academic departments. In accord with the philosophy underlying this programme, all of the research activity will move to the new building as soon as this is completed.

The core research team of the Centre comprises five Principal Investigators and the initial research programme consists of 21 projects under the following research themes: new measuring methodologies, cellular and molecular engineering, biomaterials, biomechanics and biofilms.

#### INSTITUTE FOR IMMUNOLOGY AT NUI MAYNOOTH

The Institute for Immunology at NUI Maynooth was established in 1999 following recognition of Centres of research excellence at the University and the award of major funding under the Irish Higher Education Authority (HEA) Programme for Research in Third-level Institutions (PRTL). The Institute will be housed in a dedicated Biosciences research building, funded through £9million public and private support under the HEA PRTL programme, to be completed by the end of 2001. The Institute is temporarily located in the Biology Department, The Callan Science Building at NUI Maynooth.

The overriding aim of the Institute is to conduct internationally competitive research of the highest standard in the discipline of immunology and to train individuals at undergraduate, postgraduate and postdoctoral level to become future leaders in this area.

NUIM has built a solid foundation in immunological research over the past six years and currently has several Internationally recognised Scientific Investigators. The track records of Investigators at the Institute for Immunology in their respective research fields is outstanding, with substantial research funding from The Wellcome Trust, The European Commission, The Health Research Board, Enterprise Ireland and Industry. Further recognition of excellence in research can be judged by a large number of peer-reviewed papers in high impact research journals that achieve the widest possible dissemination. International recognition of expertise in the field of Immunology is also recognised through inclusion on Grant review boards, Working groups, Invitations to speak at International scientific conferences, and acting as Peer Reviewer for several high quality International Journals

Current and future research areas include:

- Immunity to infectious diseases – pertussis, diphtheria, mumps, influenza, hepatitis C and HIV
- Vaccines and mucosal adjuvants
- Mucosal immunology of the respiratory tract
- Cell death and survival
- Tumour biology and cancer vaccines
- Immunomodulation of Th1/Th2 cells
- Neuroimmunology and inflammation

#### INSTITUTE FOR BIOENGINEERING & AGROECOLOGY AT NUI MAYNOOTH

The Bioengineering & Agroecology group combines the expertise of six very successful researchers, who are at present dealing with genetically or physiologically modified organisms for use in plant production for the future. The six permanent academic staff members of the group represent expertise in molecular biology and genetics of invertebrates, plant physiology & transformation technology, molecular biology and genetics of bacteria, population ecology of pests & disease organisms, environmental physiology and behaviour, and plant molecular & developmental biology.

The Bioengineering Group collaborates with five universities and four industrial partners in Ireland. It also collaborates with twenty-three overseas universities, five overseas industrialists and sixteen overseas research institutes. Particularly strong links are being established with Teagasc (The Irish Agriculture and food research organisation) and DANI (The North of Ireland agriculture research organisation).

The objectives of the Institute are to:

- combine genetic and physiological engineers with gene and biocontrol ecologists, in an initiative (A Centre of Excellence) to carry out bioengineering of plants and biocontrol organisms for ecological safety and sustainable production of future crops.
- promote the highest traditions of free collaborative and personal research towards the understanding of fundamental biological principles involved in this endeavour, and to the application of that understanding in the service of economic development and human welfare.
- offer the highest level of intellectual challenge, and training excellence, to post-graduate and undergraduate students
- provide scientific opinion to regulators, decision-makers and the community at large.

#### DIGITAL SIGNAL PROCESSING RESEARCH GROUP AT UCD

This group was set up at UCD in 1980. The group comprises some 20 staff. Digital Signal Processing (DSP) is a key enabling technology in telecommunications, essential for advanced mobile communications, the Internet, multimedia systems etc. The discipline is highly mathematical in nature and this is a major reason why there is a worldwide shortage of experts in the area. In the last 20 years the DSP group at UCD has produced over 60 research graduates at masters and Ph.D. level. Most of these stayed in Ireland and because of this there are now several companies in Ireland working at the very highest level in DSP (Massana, SSL, S3, Lake Communications, PMC-Sierra Ireland (formerly Toucan Technologies)). The DSP group in UCD continues to assist these companies by supplying top class research graduates and through consultancy and co-operative projects. These companies are typically working on the underlying technologies that will fuel future broadband communication systems. The rarefied specialisation of these companies is reflected in the fact that they have only a handful of competitors worldwide, and in the extremely high price-to-earnings that some of these companies command on the world's stock exchanges.

The DSP group at UCD has contributed significantly to the development of Ireland's reputation as world recognised centre for DSP expertise, both commercial and academic. Since 1992 the Group at UCD has hosted a Teltec Ireland Centre and this provided Government funding for collaborative work with industry. This important work needs to continue as local Industry will continue to rely heavily on the research and trained personnel output of the UCD group. Advanced work in UCD is now focused on communications requirements for the next 20 years.

#### COGNITIVE & COMPUTATIONAL NEUROSCIENCE CENTRE AT UCD

The Cognitive & Computational Neuroscience Centre has a total of 11 faculty from 5 different departments are involved in the centre, with upwards of 4 post-docs and 30 postgraduates engaged in this work. The Centre brings together an inter-disciplinary group of researchers in Computer Science, Pharmacology, Philosophy and Psychology to tackle fundamental questions on a range of phenomena in Cognitive and Computational Neuroscience; phenomena like learning, natural language processing and thinking.

Each of the core disciplines provides accounts of mental activity at different levels of granularity, based on computational models and tools from Computer Science. Taking a fundamental ability like learning, in Neuroscience, it is now feasible to characterise the neural changes that occur when learning takes place and trace the neurological pathways and regions involved in this mental act. In Psychology, we can characterise the informational contents of learning in precise computational models that can predict behavioural outcomes. From Philosophy, comes the conceptual tools for analysing and assessing the solutions to the question of the relationship between the mind and the brain built up over the last 3,000 years. Beyond these fundamental issues, the Centre also develops software tools that have practical implications for the information technology and pharmaceutical industries.

The Centre effort has established a Master's program in Cognitive Science. It has also attracted funding from national and international agencies for its research work. CCNC is a unique experiment in inter-disciplinary research which may prove to be an important model for such collaborations in the future.

#### SMART MEDIA INSTITUTE AT UCD

Established in 1999, the Smart Media Institute co-ordinates the research in multimedia, advanced internet applications, mobile computing, artificial intelligence, networks and telecommunications, integrating a diverse group of researchers with a research record going back to 1984. The Institute has some 72 research personnel which makes the Institute the largest concentration of leading researchers in this area in Ireland.

In the last five years, research by the Institute's members has attracted over £3M in research funding from industrial partners (e.g., Apple, Ericsson, Xilinx, Lake Electronics, S3), and national (National Software Directorate, Enterprise Ireland) and international (European Commission, US Office of Naval research) funding agencies. SMI members won 25% of the Enterprise Ireland Basic Research grants in 1999. In 2000, the Institute won unprecedented funding, in a European context, from the US Office of Naval Research one of the leading sponsors of advanced IT projects. Furthermore, the Institute's proposal for the "FutureInformation Ecosystem" came first in the Mathematics & Engineering Panel of the Marie-Curie Fellowships winning out over 200 applications from across Europe. Members of the Institute have been, in many cases, the first Irish researchers to publish in the world's leading Computer Science journals and have won leading international awards for their research.

It is a policy of SMI to spin off its research developments into patents and campus companies. Several national and international patents are also held by the members in collaboration with UCD, University of Washington, Philips, & Hitachi.

#### BIOENGINEERING RESEARCH CENTRE AT UCD

The Bioengineering Research Centre (BRC) at UCD was founded over a decade ago as a joint venture between UCD and TCD, supported by funding from Eolas. BRC has traditionally focused on biomechanics and biomaterials research in the trauma and orthopaedics areas, with collaboration with electronic and electrical engineering in the gastrointestinal field. Research is carried out in a range of areas, including development of synthetic bone graft materials, bioceramic coatings, fracture behaviour of cancellous bone and bone cement, and the biomechanics of the elbow and shoulder. This work has been published in international journals, and has been presented at conferences both at home and abroad.

Current research activities include mechanical properties of cancellous bone tissue, sialon ceramics for articulating surfaces in joint prostheses, remodelling of bone following periosteal stripping, fatigue fracture of the cement mantle in total hip arthroplasty, biomechanics of the human elbow, modelling of the resorption and mechanical properties of PLLA intramedullary nails synthetic bone graft materials, biomechanical validation of ergonomics software and modelling of scoliosis of the human spine.

There are close linkages between BRC and the medical community, with the bioengineering group at TCD, with RCSI, with QUB, with the Institute of Technology, Sligo, with the University of Oxford, Imperial College and others.

The centre has industrial linkages with DePuy/Johnson & Johnson, McGhan, National Medical Care, Donovan Medical, Stryker Howmedica Osteonics, Sofamor-Danek, Sulzer and others.

#### CENTRE FOR COLLOID SCIENCE AND BIOMATERIALS AT UCD

The Centre has developed seven technology platforms in the areas of assisted or self-assembly of soft materials composed of non-toxic biomolecules, "soft" surface coatings that are biocompatible and non-toxic, novel non-toxic bio-compatible polymers by the alliance of physical cell lines and physical chemistry, cell interaction with soft materials, instrumentation, theory and advanced computational methods. These technology platforms are shared between UCD and QUB. The platforms have been used as a basis to consolidate research and to build relationships with companies in a number of niche markets including the science technology and medical informatics market, the food and drink market, the medical device, pharmaceutical and biotechnology markets.

Over the last 4 years, the Centre has:

- published in excess of 200 academic publications in prestigious international journals. The Centre's members have been active in many international roles and have recently hosted the European Colloids Interface Society in Dublin.
- created intellectual property which has increased its profile as an international research player whilst developing novel, commercial opportunities. Many of these opportunities have been exploited in product development with industrial partners and other opportunities have been incubated as commercial concepts, some of which have turned into companies e.g. Cell Media and Intelligent Biomaterial (at the incubation stage).
- secured new funding most of which has commercial association or backing, in addition to its original International Fund for Ireland funding. The Centre has live and active partnerships with over 20 companies in the food and biomedical industries in Ireland and abroad.
- developed into a Centre which has achieved recognition for its research excellence on the world stage. It has also fostered an ethos and environment that nurtures the synergy between state of the art research and the need for commercialisation and also provided a fertile training ground for a cadre of innovative, entrepreneurial graduates.

#### IRISH NATIONAL CENTRE FOR BIOINFORMATICS

The Centre was established in 1986, under a broadly based Steering Committee, and provides computational infrastructure for Irish molecular biologists and biomedical researchers. This is achieved by maintaining software and databases appropriate for bioinformatic research and by running training courses to promote the effective use of these tools and those found on public domain internet servers. These services are currently provided to more than 300 researchers, representing all Irish universities and several of the Institutes of Technology. In 1999 the Centre won a contract to gather together and archive all available training resources in bioinformatics.

The Centre maintains a cluster of 3 DEC Alpha workstations with more 50 Gbytes of disk and a maximum of 320 MB of RAM.

The Centre's four day, 24 contact hour post-graduate training programme in bioinformatics continues to be much in demand. The course was offered in TCD in September and December 1999 and was 2x oversubscribed each time. The same course, developed in TCD, was taken to UCG in January 1999, and Athlone IT and UCC in June 1999. In all 140 post-graduate students took the course in 1999. The programme was taken to Pretoria and Cape Town South Africa in November. These were the first formal bioinformatics courses ever given in Africa.

#### INSTITUTE OF BIOSCIENCES AT UL

The Institute of Biosciences at UL is an inter-disciplinary group carrying out a range of internationally recognised applied biotechnology research. Work on safety of minimally processed food is internationally recognised, as is related research on nutraceuticals. This research has been funded by the EU and the Department of Agriculture into a unique niche area of minimally processed foods. Sport and equine science programmes have internationally recognised research programmes on biomechanics and muscle function particularly relating to the aged. Research on molecular aspects of antibiotic resistance and resistance gene transfer is part of a major European programme on gene flow and has been the focus of a recent international conference on antibiotic resistance at UL. Other related research has focused on novel penicillins, which have the potential to overcome beta lactamase resistance and have been the subject of a number of recent patents. Research on novel biosensors is being carried out in collaboration with a major US biosensor manufacturer and forms part of the North/South BEST centre for sensor research between UL, DCU and the University of Ulster.

The interdisciplinary group carries out applied research on bioengineering aspects blood flow, implant device structure and bioelectronics. This group is composed of UL research personnel, associated medical personnel at the Regional Hospital and a number of industrial research groups. Related work looks at biomaterials research and the biocompatibility of novel biomaterials. Recently the GE Foundation in the US sponsored the equipping of a tissue culture unit for biocompatibility research at UL. These groups focusing on basic and applied biological research are seen as contributing to both regional and national needs.

#### CENTRE FOR RESEARCH IN COMMUNICATIONS TECHNOLOGY AT UL

The centre, which involves 19 academics. In the past 10 years over £6 million has been obtained in project funding including 23 EU projects, 33 Enterprise Ireland / Forbairt / Eolas projects and over 100 other projects funded by Irish and International Industry. Over 110 research students have graduated with Masters or Ph.D. degrees and the group have produced over 200 journal and conference publications in the past 5 years. In 1999 the centre secured a £2million EU ESPRIT contract, (with NMRC and Analog Devices) the biggest single Irish EU contract.

Involvement in other EU programmes such as ACTS have placed the centre at the leading edge in the area of mobile communications. This has led to working with global industrial partners such as Analog Devices, IBM, Intel Cop, Sun Microsystems, Westinghouse, Ericsson, Invensys and GTE. Also within the grouping is a research team on quality, productivity and reliability in ICT - this team was selected by NOKIA, following an exhaustive international competitive review process, as the academic group around which NOKIA will build their global research effort in this area.

The centre has a track record of technology transfer, witnessed by on-campus organisations such as the Microelectronics Application Centre (MAC) and the PAT's (PEI, TELTEC, AMT) which have a collective industrial income in excess of £2m., as well as spin-off campus companies such as, Ashling Microsystems, Inspectron, Intepro (Schaffner), Piercom, and the development of the e-park.

#### PLASMA RESEARCH LABORATORY AT DCU

The Plasma Research Laboratory was established in 1996 in the School of Physical Sciences at Dublin City University, Ireland. The laboratory has extensive experience in plasma diagnostics, negative ion formation and the modelling of various low temperature plasma systems and plasma surface interactions. ASSOCIATION EURATOM DCU is based in PRL, the Association has partners in UCC, UCD and DIAS. Association EURATOM-DCU is oriented towards diagnostics contribution on COMPASS, TCV, ASDEX-Upgrade, JET and RFX, on some theoretical aspects of Fusion physics, and on negative ion sources for the development of negative ion-based neutral beam injection. Association EURATOM-DCU also provide enormous opportunities for collaboration between Dublin City University with other European Association, including Association EURATOM-CEA (Cadarache), Association EURATOM-FOM (Amsterdam). The Association an annual budget of approximately 1M ECU. There are approximately 50 people involved in the association contributing approximately 25 person years to the fusion effort. The Association is currently submitting its draft work programme and draft budget for 2002. The laboratory has over 100 referred publications and 200 contributed conference papers.

#### RESEARCH INSTITUTE FOR NETWORKS AND COMMUNICATIONS ENGINEERING AT DCU

Telecommunications has been a substantial research and educational focus in DCU since the early 1980s. Building on a track record over many years in telecommunications education and research, the success of the TELTEC centre, and the build-up of a substantial team of researchers in relevant research disciplines on campus, RINCE was established as a large scale Research Institute in Networks and Communications Engineering in 1999.

From its present base of 30 staff and 25 research students, RINCE is scheduled to grow to 100 researchers over the next 3 years. The Institute pursues an integrated programme of research in the field of Information and Communications Technologies, an area of long-term strategic importance to Ireland's social and economic development.

The Institute undertakes a range of projects in the area of networking. In order to encourage interaction between the various research groups which comprise RINCE, its research activities are co-ordinated around a number of unifying themes. These are high-speed networking, mobility of users and applications and the user interface.

The suite of projects currently being undertaken at the Institute, addressing these themes, includes projects on Network Modelling, Telecommunications Network Planning and Design, Distributed Network Management, User Quality of Service Guarantees, Radio over Fibre and Video/Audio Coding for Telecommunications and Multimedia Applications. This mix of projects is intended to address the three themes in an integrated way. The expectation is that the interactions between projects will stimulate new ideas, given the range of engineering disciplines which are involved in bringing new networking applications to fruition.





29 Upper Pembroke Street,  
Dublin 2

Tel: 01 662 5895  
E-mail: [circa@circa.ie](mailto:circa@circa.ie)

10 Lower Mount Street  
Dublin 2

Tel: 01 676 4948  
Fax: 01 662 2815  
E-mail: [chiu-info@chiu.ie](mailto:chiu-info@chiu.ie)  
Website: [www.chiu.ie](http://www.chiu.ie)

*Comhghairm Cheannairí  
Ollscoileanna Éireann*

*10 Sráid an Mhóta Íocht  
Baile Átha Cliath 2*