Ophthalmology research

Ophthalmology research at the Royal Victoria Eye and Ear Hospital benefits from strong collaborations with other research groups at the Royal College of Surgeons in Ireland, Dublin City University and Trinity College Dublin. There is an emphasis on clinical and translational research, where patient-focussed laboratory investigations aim to improve patient care through the development of new treatments. Clinical research at the hospital is strongly supported and funded by the Royal Victoria Eye and Ear Hospital Research Foundation, which has relied on charitable donations to support medical research since it was founded in 1974.

Current Research

Genetics Research

Working with Irish families with autosomal dominant forms of the inherited retinal degeneration, Retinitis Pigmentosa (RP) and in collaboration with the Ocular Genetics Unit at Trinity College Dublin, Foundation researchers were instrumental in identifying the first disease-causing gene in any form of RP, rhodopsin, in 1989. Subsequently other RP causing genes were identified in families who were characterised at the Foundation, namely the Peripherin/RDS and the mitochondrial MTTS2 genes.

At present, patients with inherited retinal degenerations face inexorable loss of vision, in many cases resulting in total blindness. However, as a result of the molecular genetic advances with which the Foundation has been intimately involved, realistic prospects now exist to give hope that treatments will become available in the foreseeable future. At the Foundation, we aim to continue to be at the forefront of research which will eventually result in the development of sight-saving treatments for these patients.

In the past year we identified two novel functions within the Rhodopsin gene in patients attending the Unit. The clinical phenotype associated with one of the mutations was reported at ARVO 2010, in Fort Lauderdale, USA.

Projects

1. **A) Age-related macular degeneration (AMD)**
   Age-related macular degeneration is one of the most common causes of visual impairment in the Irish population. Although many risk factors for the condition have been identified, recent research has highlighted the significance of genetic factors in increasing the risk of an individual developing this disease. A large-scale study into the genetics of AMD is presently underway at

the Foundation to characterise the importance of genetic risk factors in the Irish AMD population.

2. **Retinitis Pigmentosa (RP)**

B) ADRP with Choroidal Involvement associated with Asp477gly Mutation within the Rpe65 Gene

In a collaborative research effort between the Research Foundation at the Royal Victoria Eye and Ear Hospital and the Ocular Genetics Unit at Trinity College Dublin investigators identified a new gene responsible for a form of autosomal dominant Retinitis Pigmentosa. The results were published in October 2011. Linkage testing using Affymetrix 6.0 SNP Arrays mapped the disease locus in TCD-G, an Irish family with autosomal dominant retinitis pigmentosa (adRP) ascertained and clinically characterized at the Foundation to an 8.8 Mb region on 1p31. Candidate gene and exome sequencing resulted in the identification of an Asp477Gly mutation in exon 13 of the RPE65 gene tracking with the disease in TCD-G. The Asp477Gly mutation was not present in Irish controls, but was found in a second Irish family identified at the Foundation, provisionally diagnosed with Choroideraemia, but in whom no Choroideraemia gene mutation had been found. Mutations in RPE65 are a known cause of recessive Leber congenital amaurosis (LCA) and recessive RP, but no dominant mutations have been reported. This important paper (A dominant mutation in RPE65 identified by whole-exome sequencing causes retinitis pigmentosa with choroidal involvement. Bowne SJ, Humphries MM, Sullivan LS, Kenna PF, *et. al.* Eur J Hum Genet. 2011 Oct;19(10):1074-81. doi: 10.1038/ejhg.2011.86. Epub 2011 Jun 8) documented for the first time a dominantly acting mutation in this gene in 2 families with a clinical picture somewhat reminiscent of Choroideraemia. Approximately 20% of patients with a diagnosis of Choroideraemia do not have mutations in the X-linked gene for Choroideraemia. It is likely that mutations in RPE65 may be responsible for the disease in these patients.

Gene therapy for LCA patients with RPE65 mutations has shown great promise, raising the possibility of related therapies for dominant-acting mutations in this gene. A second, Canadian human clinical trial, showing promising effects of oral administration of a 9-cis-retinal analogue in patients with LCA due to recessively acting RPE65 mutations, may also hold out the prospect of beneficial effects in patients with Retinitis Pigmentosa due to dominantly acting RPE65 mutations.

a) Registry of Irish Patients with Leber Congenital Amaurosis and Early Onset Severe Retinal Dystrophy

Wellcome Trust – HRB Centre for Clinical Research, Molecular Medicine Ireland, P. Kenna (RVEEH) , M. Cahill (RVEEH), D. Keegan (MMH), I. Flitcroft (MMH).

This collaborative research co-ordinated by Mr. P. Kenna of the Research Foundation at the Eye and Ear Hospital and Mr. David Keegan of the Mater Misericordiae Hospital aims to identify Irish patients with Leber Congenital Amaurosis or Early Onset Severe Retinal Dystrophy (EOSRD), conditions in which gene mutations in the RPE65 gene have been identified. The aim is to document the incidence of these rare inherited disorders in the Irish population and to identify those individuals who might benefit from the encouraging results of the on-going clinical trials of gene therapy in these conditions.

b) Genetic Characterisation of a population of Irish Retinal degeneration patients

The study, funded by the Health Research Board of Ireland aims to analyse the DNA of a cohort of Irish patients with a variety of inherited retinal degenerations using next generation gene sequencing technology. This is a collaborative effort between Mr. P. Kenna of the Research Foundation, The Royal Victoria Eye and Ear Hospital and Prof. G. Jane Farrar at the Genetics Department, Trinity College Dublin.

(Paul Kenna)

Retinal disease

The Research Foundation has funded a trial project also to improve the diabetic retinopathy screening service in the hospital. The Research Foundation is the principal investigating site in Ireland for a number of drug trials involving anti-VEGF medications for the treatment of retinal diseases. This collaboration with pharmaceutical companies is a new avenue for the Research Foundation and we hope to develop this facility in the future

Projects

1) **Objective three-steps grading of digital fundus photographs of diabetic retinopathy.**

This project is using objective three-step grading of fundus photographs of patients with diabetic retinopathy. 450 hospital-based patients have been screened to date. The three step process increases the quality of the grading of the screening program. A quality component has been the use of OCT to detect diabetic macular oedema. This project will be expanded in 2012 to include 2 primary practices located in Ranelagh and Churchtown. It is hoped that some of the lessons learned from this programme would be adapted by the proposed National Screening Programme which is scheduled to start by the HSE towards the end of 2012.

2) **RETAIN Study**

This is a phase 3 clinical trial investigating the use of Ranibizumab (anti-VEGF medication) for the treatment of macular oedema. The Research Foundation is the principal investigating site for the study. The project started in January 2011 and will continue until January 2013. 5 patients have enrolled in the study which requires monthly visits and extensive investigation of each patient.

3) **BRIGHTER Study**

This is a phase 3 clinical trial examining the use of Ranibizumab in the treatment of macular oedema secondary to branch retinal vein occlusion. The Research Foundation will be the principal investigator on site for this trial in Ireland. It is proposed that recruitment for the study will commence in March 2012.

4) **CRYSTAL Study**

This is a phase 3 clinical trial examining the use of Ranibizumab in the treatment of macular oedema secondary to central retinal vein occlusion. The Research Foundation will be the principal investigator on site for this trial in Ireland. It is proposed that recruitment for the study will commence in March 2012.

(Mark Cahill)

Ocular Pathology

This is a collaboration between the oncology and pathology services at the Royal Victoria Eye & Ear Hospital and Dublin City University looking at potential prognostic biomarkers in eye cancer. The pathology and ocular oncology unit at Royal Victoria Eye & Ear Hospital are also working closely with the National Institute for Cellular Biotechnology NICBI on a Research Foundation supported research programme in identifying specific proteins in patients with eye melanoma that help to predict the spread of cancer outside the eye, with the aim of improving long term patient survival.

Projects

1) Proteomic analysis of tumours and vitreous fluid from uveal melanoma

P.Ramasamy (MD Study), C.Murphy, N.Horgan, P.Meleady, M.Clynes, S.Kennedy

(Noel Horgan)

(Susan Kennedy)

Ocular Inflammation

The Research Foundation is supporting a novel long-term collaboration between the ocular inflammation/cornea service of the Royal Victoria Eye & Ear Hospital under the direction of Professor Conor Murphy and Mr William Power, the National Institute for Cellular Biotechnology (NICBI) at Dublin City University, the department of immunology at the Royal College of Surgeons Ireland and the department of Rheumatology in St.Vincents University Hospital. This collaboration brings together clinical and scientific skills from a range of disciplines which we hope will improve our understanding of a number of inflammatory eye conditions and corneal diseases and benefit patients through the development of new treatments.

Projects

1) Improving outcomes in giant cell arteritis through clinical collaboration

Clinician Investigators: Prof C.Murphy, Professor of Ophthalmology, Royal Victoria Eye and Ear Hospital and Royal College of Surgeons in Ireland; Dr E.Molloy, Consultant Rheumatologist, St. Vincent's University Hospital.

Scientist Investigator: Dr U.Fearon, Senior Lecturer in Immunology, Department of Rheumatology, Education and Research Centre, St. Vincent's University hospital.

Co-investigator: Prof J.Meaney, Consultant Radiologist, St James' Hospital.

2) Acute anterior uveitis and spondylarthropathy research project

Clinician Investigators: Prof C.Murphy, Consultant Ophthalmic Surgeon and Professor of Ophthalmology, Royal Victoria Eye and Ear Hospital and Royal College of Surgeons in Ireland; Prof O.Fitzgerald, Consultant Rheumatologist, St. Vincent's University Hospital.

Scientist Investigator: Dr U.Fearon, Senior Lecturer in Immunology, Department of Rheumatology, Education and Research Centre, St. Vincent's University hospital.

Clinician Research Scientist: Dr P.Ramasamy, Royal Victoria Eye and Ear Hospital and Royal College of Surgeons in Ireland.

3) Evasion of the innate immune response by herpes simplex virus in the cornea: molecular mechanisms mediating interferon down regulation and virus survival

Clinician Principle investigator: Prof C.Murphy, Consultant Ophthalmic Surgeon, Royal Victoria Eye and Ear Hospital and Professor of Ophthalmology, Royal College of Surgeons in Ireland.

Scientist Principle investigator: Dr C.Jefferies, Senior Lecturer in Immunology, Department of Molecular and Cellular Therapeutics, Royal College of Surgeons in Ireland.

Clinician Research Scientist: Dr D.Shahnazaryan, Royal Victoria Eye and Ear Hospital and Department of Molecular and Cellular Therapeutics, Royal College of Surgeons in Ireland.

4) Innate immunity in HSV-1 keratitis and the role of Toll-like receptor mediated immunomodulation for treatment and prophylaxis

Clinician Principle investigator: Prof C.Murphy, Consultant Ophthalmic Surgeon, Royal Victoria Eye and Ear Hospital and Professor of Ophthalmology, Royal College of Surgeons in Ireland.

Scientist Principle investigator: Dr C.Jefferies, Senior Lecturer in Immunology, Department of Molecular and Cellular Therapeutics, Royal College of Surgeons in Ireland.

Clinician Research Scientist: Dr C.Malone, Royal Victoria Eye and Ear Hospital and Department of Molecular and Cellular Therapeutics, RCSI.

5) Corneal Stem Cell Research Project

W.Power, C.Murphy, F.O'Sullivan, M.Clynes & W.Murphy

The Royal Victoria Eye & Ear Hospital, the National Institute for Cellular Biotechnology at Dublin City University and the Irish Blood Transfusion Service (IBTS) are involved in a study harvesting and then growing sheets of stem cells to produce corneal epithelium which can be used to repair diseased or damaged superficial corneal tissue surgically. The group hope to be in a position to bring this new therapy into clinical use in late 2012.

6) Investigation of miRNA expression in Fuchs Dystrophy

W.Power, P.Lee, F.O'Sullivan and M.Clynes

Fuchs endothelial cell dystrophy (FED) is a chronic, progressive corneal condition. It is characterized by the presence of central corneal guttae in the early stage and may take up to a decade from the onset before it causes debilitating symptoms due to corneal oedema. The aim of this study is to delineate the role of microRNA (miRNA) in the pathogenesis of FED. This project is a collaboration between clinicians at Royal Victoria Eye & Ear Hospital (RVEEH) and molecular scientists at Dublin City University (DCU) to further our understanding of this common condition.

(Conor Murphy)

Systemic Disease

The Research Foundation was chosen by Servier, a leading French pharmaceutical company, to do a Phase III multi-centre clinical trial to analyse the retinal effects of Ivabradine, an IF inhibitor used as cardiac rate limiter in heart disease. This trial commenced in October 2009 and will be ongoing for the next three years.

Projects

1) Long-term (3 years) ophthalmic safety and cardiac efficacy and safety of Ivabradine administered orally.

P.Kenna, L.Cassidy and H.Dempsey

(Lorraine Cassidy)

Ocular inflammation and infection research

Herpes simplex keratitis research

Herpes simplex keratitis (HSK) represents the single most important inflammatory disease of the cornea, with respect to its impact on vision and health related quality of life. It is characterised by repeated episodes of inflammation in the cornea, the clear window at the front of the eye, which leads to corneal scarring and, in many cases, loss of vision. It is caused by the common cold sore virus, known as Herpes

Simplex Virus type 1. The herpes virus has evolved in ways that enable it to evade the immune response, the way in which we defend ourselves against attack from infectious agents. This enables the virus not only to initiate infection in the cornea but also to reactivate repeatedly throughout life leading to permanent damage to the front of the eye and, in many cases, loss of vision. Our research into this condition aims to improve our understanding of how the herpes virus interacts with our immune system, particularly our innate immunity which is our first line of defense. By improving our understanding of this interaction, we hope to identify new targets for novel treatments of this disease and improve the outlook for sufferers of HSK.

Projects

Evasion of the innate immune response by herpes simplex virus in the cornea: molecular mechanisms mediating interferon down regulation and virus survival

Clinician Principle investigator: Prof Conor Murphy, Consultant Ophthalmic Surgeon, Royal Victoria Eye and Ear Hospital and Professor of Ophthalmology, Royal College of Surgeons in Ireland.

Scientist Principle investigator: Dr Caroline Jefferies, Senior Lecturer in Immunology, Department of Molecular and Cellular Therapeutics, Royal College of Surgeons in Ireland.

Clinician Research Scientist: Dr David Shahnazaryan, Royal Victoria Eye and Ear Hospital and Department of Molecular and Cellular Therapeutics, Royal College of Surgeons in Ireland.

Innate immunity in HSV-1 keratitis and the role of Toll-like receptor mediated immunomodulation for treatment and prophylaxis

Clinician Principle investigator: Prof Conor Murphy, Consultant Ophthalmic Surgeon, Royal Victoria Eye and Ear Hospital and Professor of Ophthalmology, Royal College of Surgeons in Ireland.

Scientist Principle investigator: Dr Caroline Jefferies, Senior Lecturer in Immunology, Department of Molecular and Cellular Therapeutics, Royal College of Surgeons in Ireland.

Clinician Research Scientist: Dr Conor Malone, Royal Victoria Eye and Ear Hospital and Department of Molecular and Cellular Therapeutic, RCSI.

Effect of corneal Herpes Simplex Virus-1 infection on Toll-Like Receptor expression in human peripheral blood mononuclear cells

Clinician Principle investigator: Prof Conor Murphy, Department of Ophthalmology
Scientist Principle investigator: Dr Caroline Jefferies, Senior Lecturer in Immunology, Department of Molecular and Cellular Therapeutics, Royal College of Surgeons in Ireland.

Research Scientist: Mr Ciaran de Chaumont, Department of Molecular and Cellular Therapeutics, Royal College of Surgeons in Ireland.

Giant cell arteritis research

Giant cell arteritis (GCA) is the most common form of primary systemic vasculitis (inflammation of blood vessels). Patients with GCA endure significant morbidity associated with the disease and its treatment. Significant deficits exist in our understanding of this disorder. The primary aim of this study is to identify cases of GCA on an ongoing basis, for inclusion in a GCA database. This database of GCA patients will facilitate clinical and translational research studies, audit and participation in international multi-centre clinical trials.

In this study, we are performing thorough clinical and radiological assessments of patients attending with new onset GCA with a view to correlating the findings with the long term outcome of the condition. In addition, little is known about the causes and mechanisms of this disease. We are performing laboratory investigations on the blood and temporal artery biopsy specimens of patients with GCA with the aim of improving our understanding of how this disease occurs. This will hopefully help us to use more specific and effective treatments in the future and help us to understand why some patients do not respond well to conventional therapy with steroids. In the future we will perform genetic studies that we hope will provide information about the underlying causes and long term prognosis of the disease. Sampling of blood, taking a biopsy of the temporal artery (in the temple on the side of the head), and radiological assessment are all part of the routine investigation of patients with GCA.

Project

Improving outcomes in giant cell arteritis through clinical collaboration

Clinician Investigators: Prof Conor Murphy, Professor of Ophthalmology, Royal Victoria Eye and Ear Hospital and Royal College of Surgeons in Ireland; Dr Eamonn Molloy, Consultant Rheumatologist, St. Vincent's University Hospital.

Scientist Investigator: Dr Ursula Fearon, Senior Lecturer in Immunology, Department of Rheumatology, Education and Research Centre, St. Vincent's University hospital.

Co-investigator: Prof Jim Meaney, Consultant Radiologist, St James' Hospital.

Anterior uveitis and spondylarthropathy research

Acute anterior uveitis (AAU) is characterised by the acute onset of inflammation in the front compartment of the eye, leading to pain, light sensitivity and blurred vision. It is a common reason for presentation to ophthalmic emergency departments. In approximately half of cases there is an identifiable systemic disease, most commonly the seronegative spondyolarthropathies (SpA). This is a group of inflammatory joint diseases that predominantly affect the spine but have many other manifestations including skin and bowel problems.

The aim of this collaboration with St. Vincent's Unversity Hospital Department of Rheumatology is to develop an assessment algorithm and draw up rheumatology referral guidelines that will aid the early diagnosis of the SpA in patients presenting with AAU to the Royal Victoria Eye and Ear Hospital (RVEEH). We are trying to determine the clinical features on presentation with AAU that help identify the presence of SpA and aid early diagnosis. With early detection come early and more effective treatment and disease control, and hence better quality of life.

In addition, we are assessing both vision- and general health-related quality of life by means of two short self- administered questionnaires. The questionnaires measure the impact of the disease and any associated SpA on patients' general well being and subjective visual functioning. We are also studying blood from the patients to try to identify specific genes and proteins in the blood that can be used as predictors or markers of the development of SpA in patients with AAU, as well as changes in inflammatory blood cells that may help improve our understanding of these conditions.

Projects

1. Testing a new algorithm for the detection of undiagnosed spondylarthropathies in patients presenting with acute anterior uveitis in a primary care ophthalmology setting.
2. Prospective evaluation of vision and health-related quality of life in patients with acute anterior uveitis.
3. Peripheral blood mononuclear cell activation status and functional characteristics in patients with acute anterior uveitis.

Clinician Investigators: Prof Conor Murphy, Consultant Ophthalmic Surgeon and Professor of Ophthalmology, Royal Victoria Eye and Ear Hospital and Royal College of Surgeons in Ireland; Prof Oliver Fitzgerald, Consultant Rheumatologist, St. Vincent's University Hospital.

Scientist Investigator: Dr Ursula Fearon, Senior Lecturer in Immunology, Department of Rheumatology, Education and Research Centre, St. Vincent's University hospital.

Clinician Research Scientist: Dr Pathma Ramasamy, Royal Victoria Eye and Ear Hospital and Royal College of Surgeons in Ireland.

Corneal and tissue engineering research

Corneal stem cell and tissue engineering research

The cornea, the clear window at the front of the eye, is susceptible to a host of disease processes that can lead to opacification or loss of transparency. When damaged, the front layer of the cornea called the epithelium is regenerated by specialised cells located on the surface of the eye called stem cells. In some diseases or following serious trauma to the eye, these stem cells are irreversibly damaged and cannot perform this function, leading to blindness. Following work that we and others have done, it is now possible to regenerate these cells from donor cells (i.e. from another individual) in the laboratory using a method called cell culture and transplant them onto the eye where they will repair the damaged eye surface and restore vision. Through collaboration with our partners at the NICB in DCU and at the Irish Blood Transfusion Board, we will be bringing this new technique to the clinic in the very near future for patients with cornea/limbal stem cell deficiency. We believe that will be the first stem cell treatment to become available for patients in Ireland.

Following our success with stem cells of the corneal epithelial layer, we are now focussing our efforts on the regenerating inner lining of the cornea, the endothelium, and the bulk layer of the cornea, the stroma. With our colleagues at the National Institute of Cellular Biotechnology and at the Department of Anatomy of the Royal College of Surgeons in Ireland, we are exploring the possibility of developing a fully bioengineered cornea that includes the epithelium, the stroma and the corneal endothelial cell layer that lines the inside of the cornea.

Clinician Investigators: Mr Billy Power, Consultant Ophthalmic Surgeon, Royal Victoria Eye and Ear Hospital; Dr Willie Murphy, Director of the Irish Blood Transfusion Service and Eye Bank; Prof Conor Murphy, Consultant Ophthalmic Surgeon, Royal Victoria Eye and Ear Hospital and RCSI.

Scientist Investigators: Dr Finbarr O'Sullivan, Senior Research Scientist, National Institute for Cellular Biotechnology, Dublin City University; Prof Martin Clynes, Director of the National Institute for Cellular Biotechnology, Dublin City University; Prof Fergal O'Brien, Head of Tissue Engineering and Regenerative Medicine, Department of Anatomy, Royal College of Surgeons in Ireland; Ms Sandra Shaw, Senior Scientist, Irish Blood and Tissue Service.

Visual function and quality of life in corneal transplantation

Corneal transplantation is performed to fully or partially replace the unhealthy cornea (the clear window at the front of the eye) by donated corneal tissue. Penetrating Keratoplasty (PK) uses a full thickness transplant to replace the damaged cornea. DSAEK is a relatively new type of corneal transplantation in which only the inner lining of the cornea called endothelium is replaced along with a thin layer of the stroma of the cornea. Both PK and DSAEK can achieve great visual outcomes. However their indications, postoperative management and the length visual rehabilitation vary. Visual acuity is the only measure of visual function routinely tested. However, considered alone it inadequately describes visual

performance, which can be affected by other measures such as contrast sensitivity and colour vision for example. It is becoming increasingly recognised that vision related quality of life (VR-QOL) questionnaires, which measure the global impact of visual impairment on physical, psychological, and social functioning in day to day life, provide an additional and effective means of measuring visual functioning, as has been demonstrated for patients with various ocular conditions.

In this study we are assessing the impact of corneal transplantation on visual functioning before and after corneal transplantation. By exploring patients' perceptions of their vision and health related quality of life at the same time, we will learn about the impact of the disease and the corneal transplant surgery on corneal transplant patients' everyday lives.

Clinician Investigators: Prof Conor Murphy, Professor of Ophthalmology and Consultant Ophthalmic Surgeon, Royal Victoria Eye and Ear Hospital and Royal College of Surgeons in Ireland; Mr Billy Power, Consultant Ophthalmic Surgeon, Royal Victoria Eye and Ear Hospital; Dr David Shahnazaryan, Clinical Research Fellow, Royal Victoria Eye and Ear Hospital.

Uveal melanoma research

The purpose of this study using uveal melanoma tissue specimens with long-term clinical follow-up is to identify differentially regulated proteins from the comparison of primary uveal melanoma tissue that was found not to have metastasised versus primary uveal melanoma tissue that was subsequently found to have metastasised. These differentially regulated proteins may help us to understand the rapid progression of uveal melanoma in some patients and may serve as potential biomarkers to allow prediction of metastasis and prioritisation of patients for interim monitoring and adjuvant treatment. The rationale for the study is that there have only been a limited number of proteomic studies to date investigating the biology of the metastatic phenotype of uveal melanoma. Biomarkers predicting metastatic uveal melanoma are urgently needed and would improve interim monitoring and treatment of patients who are likely to develop macrometastasis. A prospective study of the proteomics of uveal melanoma is also underway with our collaborators at the National Institute of Cellular Biotechnology at Dublin City University.

Project

Proteomic analysis of tumours and vitreous fluid from uveal melanoma patients

Clinician Investigators: Prof Susan Kennedy, Consultant Pathologist, Royal Victoria Eye and Ear Hospital; Mr Noel Horgan, Consultant Ophthalmic Surgeon, Royal Victoria Eye and Ear Hospital; Dr Pathma Ramasamy, Clinical Research Fellow and Clinical Tutor, Royal Victoria Eye and Ear Hospital and RCSI; Prof Conor Murphy, Consultant Ophthalmic Surgeon, Royal Victoria Eye and Ear Hospital and Professor of Ophthalmology at RCSI.

Scientist Investigators: Dr Paula Meleady, Senior Research Scientist, National Institute for Cellular Biotechnology, Dublin City University; Prof Martin Clynes, Director of the National Institute for Cellular Biotechnology, Dublin City University.