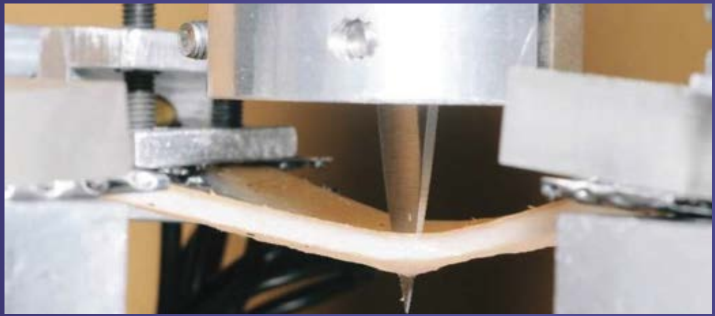
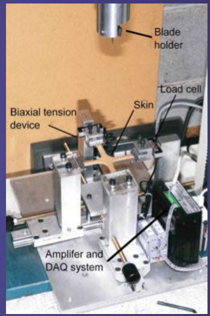
Making a Stab at Forensic Biomechanics

In recent years, the fields of biomechanics and forensic medicine have merged to form a new discipline: forensic biomechanics. This discipline has met the needs of the legal system in particular, with engineers increasingly acting as expert witnesses in courts of law.



Knife puncturing porcine skin



Biaxial tension device

With this in mind, Prof Michel Destrade, Head of Applied Mathematics at NUI Galway, teamed up with the Irish State Pathologists Prof Marie Cassidy and Dr Mike Curtis, and Prof Michael Gilchrist and Dr Aisling Ni Annaidh from the The School of Mechanical and Materials Engineering, at UCD to carry out multidisciplinary research on some of the big questions in forensic biomechanics. One such project focuses on the mechanics of stabbing.

"When a stabbing is fatal, the amount of force required to inflict the stab wound is often the source of much debate in court," says Prof Marie Cassidy. "As an expert witness, I am usually asked to quantify the force involved in the stabbing attack. The answer that I give is critical in determining the harmful intent of an assailant."

Traditionally, the pathologist assesses the force used based on the condition of the blade, the extent of the tissue damage, the presence of clothing and the wound itself, and then categorises the force as either mild, moderate or severe. "The problem with such descriptions is that they are open to interpretation," adds Cassidy. "Moderate could mean something completely different to me than it does to a juror."

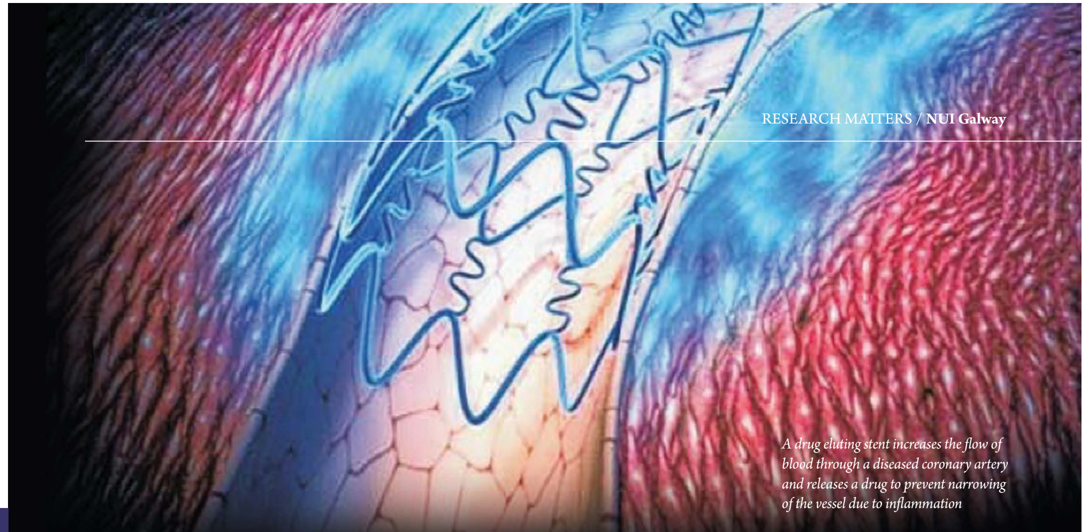
It's an unusual research interest for applied mathematicians and engineers, but this work has successfully combined experimental techniques with sophisticated finite element methods to develop a measure of the minimum forces required to puncture human skin. A series of experiments allowed for the investigation of the effect of a number of key variables in stabbings, including the thickness and tension of the skin, the angle of attack, the underlying substrate, the presence of clothing, the speed of the attack and the type of instrument used.

Based on the results, a finite element model of blade penetration was developed. The model replicates the conditions of the stab-penetration test and uses a sophisticated failure criterion to model the puncturing of the skin.

"The chief advantage of developing such a model is that once the development process is complete, the same model can be used to investigate the influence of the many factors associated with stabbing incidents," explains Dr. Ní Annaidh. "This work has lead to the development of a stab metric that can indicate the level of force used in a given stabbing incident. It has been disseminated in the best forensics journals including Forensics Science International and The American Journal of Forensic Medicine and Pathology.

"It has been a fantastic adventure to collaborate with such high-calibre experts in engineering and forensics," says Prof Destrade. "I have learned a lot and I'm excited to be able to use applied mathematics for this on-going effort to model the mechanics of stabbing."

by PROF MICHEL DESTRADE
College of Science



A drug eluting stent increases the flow of blood through a diseased coronary artery and releases a drug to prevent narrowing of the vessel due to inflammation

NUI Galway Maths Research in Focus

Mathematics at NUI Galway is more vibrant than ever with numerous research areas looking for solutions in key areas, particularly medicine and biology.

Mechanics of the Brain

The mechanics of the brain are being investigated in order to gain better understanding of the physical properties of brain tissue – an under-researched area where greater levels of understanding could assist in a variety of medical treatments.

Prof Michel Destrade, Head of Applied Mathematics at NUI Galway, teamed up with Prof Michael Gilchrist and Dr Badar Rashid in Mechanical Engineering at UCD to address this knowledge gap. They conducted a series of experiments on porcine brain matter in order to model and simulate the mechanical properties of the brain. They also studied the microstructure of brain matter

Polymer Free Stents

Eighty percent of global stent production is carried out in Ireland. Stents are a major mechanical tool in the treatment of blocked coronary arteries. Dr Martin Meere from the School of Mathematics at NUI Galway has teamed up with the National Centre of Biomedical Engineering Science (Galway) to propose sound mathematical models of drug release from polymer free stents. They hope to help identify the dominant mechanisms involved in drug release and help quantify how the release behaviour depends on the geometrical and material properties of the system. Eventually their research should assist in the design of better stents.

Visualising Decision Space

One way to conceptualise how we make decisions is to consider our possible choices as "attractors" in a "decision space". We make a decision when our behaviour reaches the vicinity of one of these equilibria. By tracking how individuals make their choices, for instance through the trajectory of a computer-mouse choice, it is possible to infer the pull towards available responses prior to the eventual response, and in so doing, to infer characteristics of the decision space where these choices exist.

Dr Petri Piiroinen at the School of Mathematics and Dr Denis O'Hora at the School of Psychology in NUI Galway have devised a method to visualise and analyse decision spaces. They are currently developing new tools to analyse dynamical decision-making, based on the modeling of behavioural experiments conducted at the university. Their preliminary results have just been published in *Nature Scientific Reports.*

Bio-informatics

Bio-informatics research at NUI Galway includes understanding how mutations cause drug resistance in Leishmania, a neglected tropical pathogen, from analysis of genome sequences; assembly and analysis of the genome of Hydractinia echinata, a new model organism that is being used to study stem cell regeneration and cancer at NUIG; analysis of the structure and function of DNA in difficult-to-sequence regions of the human genome that were neglected by the Human Genome Project; development of new probabilistic tools to understand how some human antibodies can control HIV by targeting specific parts of the virus; and understanding how proteins interact with one another, forming complex networks that are an important aspect of how cellular systems work. In many cases we can analyse large amounts of genomics data that are now being shared globally, while also enabling NUIG researchers to benefit from advances in genomics technologies.

Computational Algebra

A de Brún Centre team are using algebra to design and compute shape invariants for proteins, data sets, fractals, networks, medical images, hyperbolic space, number theory, group theory etc.

Biostatistics

Biostatisticians are working to improve and better understand optimum Sugar Cane Growth, anti-malarial drug interactions, HIV outcomes, etc.