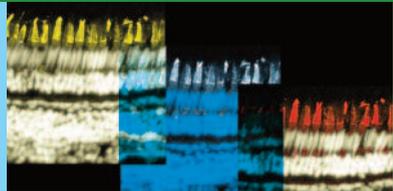




# UCD SCIENCE SHOWCASE



VOLUME 3

# Welcome

I am very pleased to introduce Volume 3 of our UCD Science Showcase Series. The purpose of this publication is to share stories of UCD Science research and education with the public, government agencies, industry and university colleagues alike. We want to acknowledge a cross section of our academics, whose work is described here. However, it represents only a small sample of the huge variety of research and educational activities that take place in UCD. Such is the talent base that we could easily have material for several volumes of such stories per year. Interviews featured were with Dr Claire O'Connell, science writer and journalist.

The UCD College of Science covers core and applied disciplines including biological, chemical, geological, mathematical, physical and computer sciences as well as finance, actuarial sciences, meteorology and biopharmaceutical sciences. Disciplines are represented through seven Schools: Biology & Environmental Science, Biomolecular & Biomedical Science, Chemistry, Computer Science, Earth Sciences, Mathematics & Statistics, and Physics. In addition to

Schools playing an important role in education programmes they act as host for each academic in the wider university context.

Increasingly big questions require answers that draw on a multitude of skills, often situated at the interface of disciplines. UCD Science academics collaborate with colleagues in other UCD Colleges or universities to look at green energy and the environment, biomedical research, complex numerical systems, nanotechnology, sensors and the interface of biology and technology. I am very pleased to see new collaborations emerge and existing ones yield impactful outcomes.

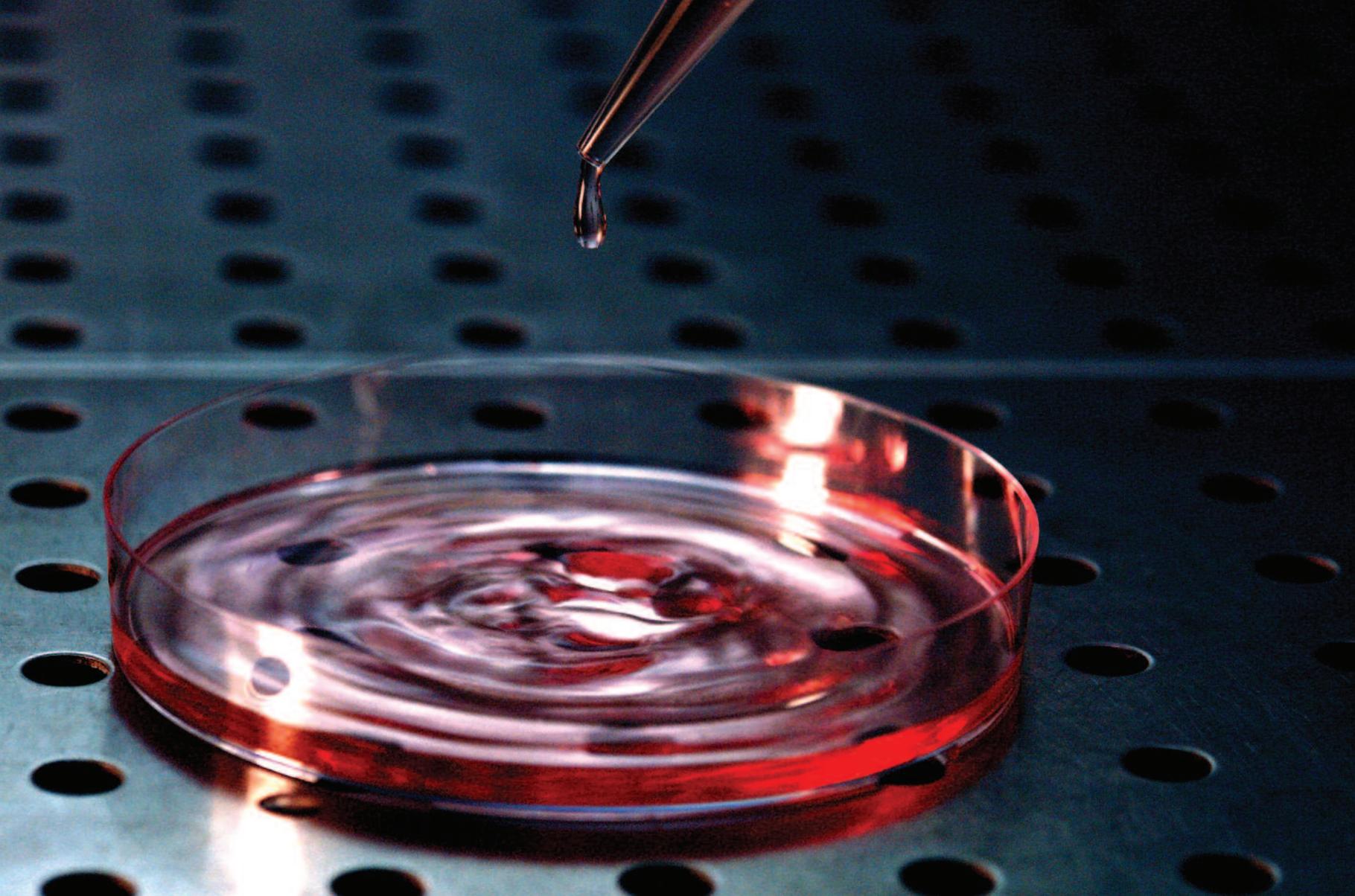
Research in the sciences is an expensive activity and I want to gratefully acknowledge the support our researchers receive from the Irish state and its agencies, EU agencies, international trusts, industrial sponsors and individuals.

**Professor Joe Carthy**

UCD College Principal and Dean of Science

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The background is a dark blue gradient with several bright, glowing blue light streaks and curves that create a sense of motion and depth. The text is positioned in the lower right quadrant.

UCD Science Showcase 3  
Health



## Dr Orina Belton

*Senior Lecturer - UCD School of Biomolecular & Biomedical Science*

### *How to turn the bad guys good in hardened arteries*

Hardening of the arteries, or atherosclerosis, is one of the most common cardiovascular diseases and is a common feature of ageing but it is not good news. When complex, calcified fatty plaques accumulate and develop up on the inner surface of major arteries, it pushes up the risk of heart attack and strokes.

That's why Dr Orina Belton is figuring out how targeting a key cell of the immune system could change the nature of plaques, and possibly even reduce the damage.

"Hardening of carotid arteries is a progressive inflammatory disease and is a major risk factor for clinical events such as a heart attack and stroke - and ageing, lifestyle, high blood pressure, high cholesterol and diabetes are major drivers of this disease," explains Dr Belton, who is a Senior Lecturer in Pharmacology at the School of Biomolecular and Biomedical Science.

*"But by the time a person is diagnosed with atherosclerosis, the plaques are often well established and there are currently no therapies that can regress the established plaques."*

Dr Belton has been looking at how a type of immune cell called a macrophage is involved in plaque building, and how those cells could be 'programmed' to help plaques regress instead. Macrophages come in initially as 'good Samaritans' and soak up excess cholesterol in plaques, but in an atherosclerotic environment the cells dump the fat into the artery, sustaining the disease and contributing further to hardening, she explains.

Her work has been finding that administering a precise ratio of conjugated linoleic acids (CLAs) seems to alter how the macrophages behave. "The macrophages change function and they move away from the plaque," says Dr Belton.

## Key research interests:

Atherosclerosis

Inflammation

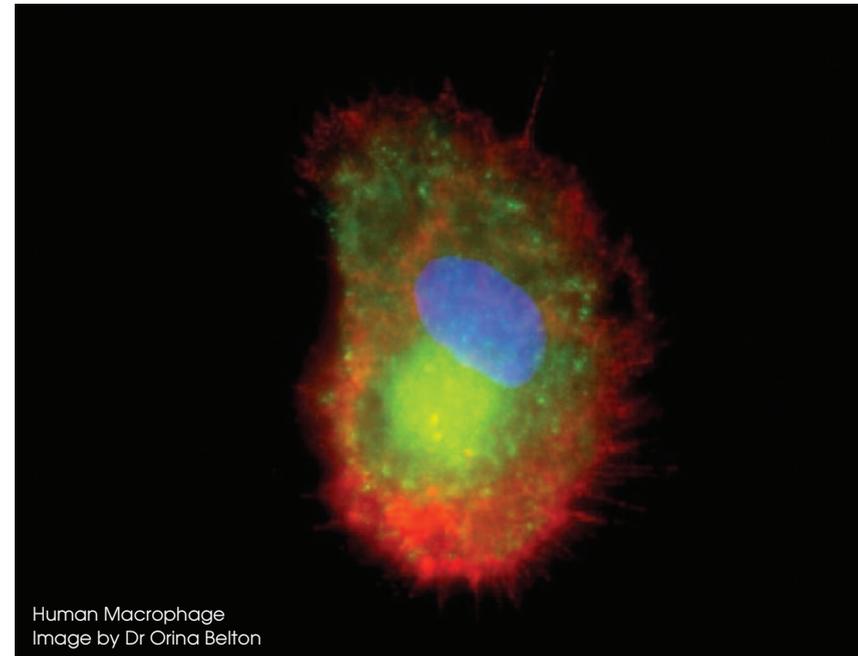
Complications of Type 2 Diabetes

Novel therapeutic targets

Pre-clinical work suggests that 'reprogramming' the macrophages with this blend of lipids reduces the size of plaques, but the lipids themselves would not form the basis of a therapy, so a major aim of Dr Belton's research is to identify how the macrophages get reprogrammed. "We have been uncovering some novel biochemical pathways that get turned on to make this happen," she says. "And when you fundamentally alter the macrophage you change the microenvironment of the plaque, and this is what we believe can cause the plaque to shrink or regress."

Dr Belton is also looking at genes expressed in blood samples and plaques that have been surgically removed from consenting patients at the St. Vincent's University Hospital to compare patients who have had a cardiac event or stroke and patients who have hardened arteries but no 'events'.

"The ultimate goal is if to find a way to specifically target that macrophage response in atherosclerosis so that when you see people with risk factors at the start of the disease you could intervene earlier and stop the progression of the disease, that would be really significant," she says. "And if this macrophage switch happens in other inflammatory diseases too, like chronic kidney disease or diabetes, then understanding the trigger for that switch would have a huge impact."



Human Macrophage  
Image by Dr Orina Belton



## Dr Cormac Murphy

Senior Lecturer - UCD School of Biomolecular & Biomedical Science

### *A superhero fungus for better drugs*

In the wild, *Cunninghamella elegans* is a pretty humdrum fungus. It hangs out in the soil, particularly near coastal areas, and it is generally harmless to humans. But *Cunninghamella* is a superhero when it comes to testing and developing drugs in the lab, and Dr Cormac Murphy is harnessing its power.

“Enzymes called cytochromes P450 are involved in drug metabolism in humans and in other mammals in our liver, and *Cunninghamella* has cytochromes P450 as well,” he explains. “And numerous studies have shown that for different drugs *Cunninghamella* does metabolise drugs in the same way as mammals.”

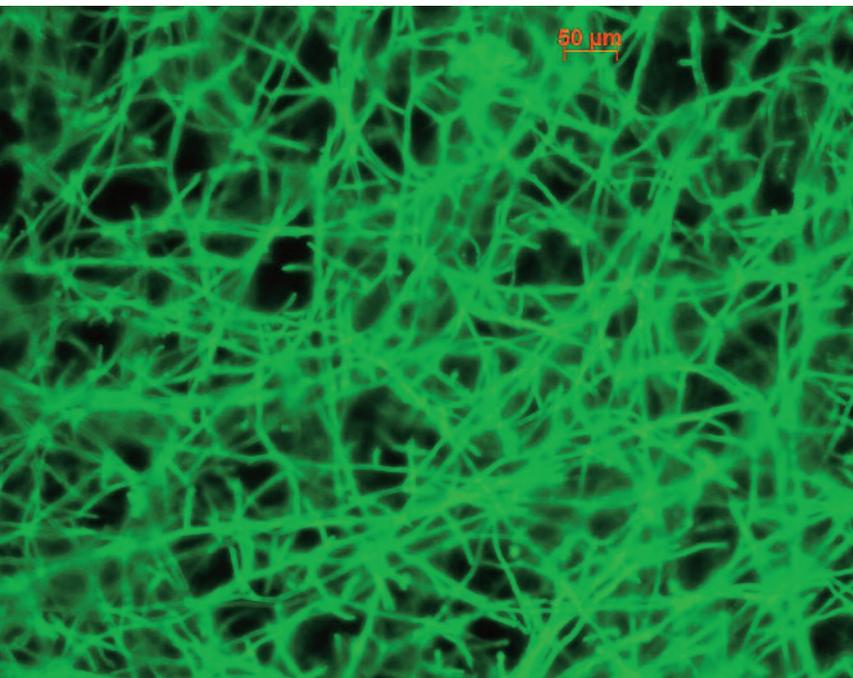
When drugs are broken down - whether in the liver or in the fungus - it results in chemicals called drug metabolites, and regulatory bodies in medicine want evidence that such metabolites don't themselves pose a safety issue.

This is where Dr Murphy, a Senior Lecturer, School of Biomolecular and Biomedical Science, sees *Cunninghamella* offering a useful service. “It's relatively easy to grow these micro-organisms in the lab in large numbers, and you can add your drug to the fungal cells growing in the flask, then the fungus will produce the metabolites that you want to test,” he says. “We think this has the potential to be more efficient than producing the metabolites through organic chemical synthesis or dosing laboratory animals - the fungus does the work for you.”

Dr Murphy and his lab have also discovered that when the fungus forms a 'biofilm' or flat aggregation of cells that stick together, they can produce metabolites even more efficiently. “Biofilms are hard to kill and can be bad news when they form on medical equipment, but in this case the stability of the biofilm is a good thing,” he says. “It means that instead of growing the fungus in a huge big vat, we can grow it in a smaller volume and the fungus is active over a much longer period of time.”

## Key research interests:

Fungus  
Fluorine  
Drug  
Metabolism



Cunninghamella elegans magnified by fluorescence microscopy -  
Image provided by Dr Cormac Murphy

The fungus can also help scientists to fine-tune drug compounds, adds Dr Murphy, who together with colleagues at the University of Durham has developed a *Cunninghamella*-based system to work out where putting a fluorine atom on a drug could slow down its metabolism.

“We have found that by putting a non-fluorinated drug into *Cunninghamella*, and tracking how it is broken down, we can predict the best sites for fluorine,” he explains. “Then our collaborators in Durham make the fluorinated drug and we test it out on the fungus. Using this method we have been able to completely stop metabolism of the potential drug, which is quite neat.”

Aside from drug testing and development, *Cunninghamella* also seems to have a talent for taking dyes out of water, which could be of interest to the global textile industry, adds Dr Murphy. “We can remove the dye malachite green from water just using the fungal biofilm,” he says. “You can see the liquid going clear and the fungus goes green at first, then the colour disappears from the biofilm, and we could use the same biofilm for a month, it just kept on working. So the fungus has a number of uses, we are trying to squeeze the most out of it.”



## Dr Hilary McMahon

Lecturer – UCD School of Biomolecular & Biomedical Science

# *How to protect against problematic prions?*

If you watched news bulletins in the 1980s and 1990s, you will be instantly familiar with Bovine Spongiform Encephalitis (BSE or ‘mad cow disease’) and its human equivalent, variant Creutzfeldt-Jakob Disease (vCJD).

Triggered by abnormal proteins called prions, these distressing and ultimately fatal conditions not only caused human misery and economic loss, they were also scientifically puzzling.

Yet while BSE no longer hits the headlines as frequently, prion diseases haven’t gone away, explains UCD researcher Dr Hilary McMahon, who is developing a deeper understanding of these confounding proteins and how to stop them from causing problems.

Unlike the more familiar territory of bacteria, fungi and viruses that cause communicable diseases, prions have an unusual way of working: they are effectively ‘normal’ proteins in the brain, but if they become misshapen or ‘abnormal’, they can directly trigger a prion disorder that damages the brain.

And even the ‘normal’ prion can still cause problems: it is thought to trigger other proteins to build up and cause problems in Alzheimer’s disease.

Dr McMahon’s work on the biology of prions is unravelling the complex biochemistry of this role. “We have unearthed a new pathway of control between the prion protein and the regulation of Alzheimer’s,” she says.

Her research has also identified a role for the hormone oestrogen in the development of prion disorders triggered by the abnormal prion protein. “We recently identified oestrogen levels as being a factor in whether or not a prion disease will occur,” she says.

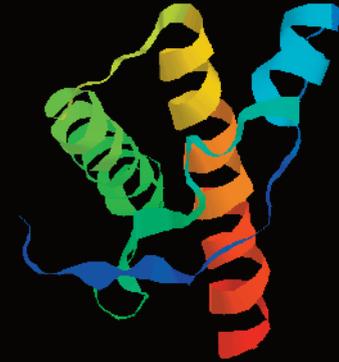
## Key research interests:

Prion  
Alzheimer's  
Proteases

Yet while the incidence of full prion disorders in humans is rare, we still need to be vigilant, according to Dr McMahon, who explains that a small number of people carry the abnormal prion but show no symptoms. “We have to always be aware that the agent is still out there and has the potential to be transferred on to others, as has happened during hospital procedures,” she says.

To help quench abnormal prion proteins before they can be passed between humans or into the food chain, Dr McMahon has been developing a new, enzyme-based approach to destroying the prion structure.

“The abnormal prion protein is very resilient to the standard methods that are used to sterilise hospital equipment,” she says. “So we have developed enzymes called proteases that degrade the abnormal prion proteins under very mild conditions.”



Prion – Image provided by Dr Hilary McMahon

The sterilising procedure could be applied not only to hospital equipment but it could also potentially stop abnormal prions from entering the human food chain, she notes. “You may be able to spray the enzyme on fields or farms and the hope will be that it will break down the prion where present.”

And it’s important that we continue to tease out the basic biology of prions, which are still relatively new to science, notes Dr McMahon. “It’s only in the last 10 or 20 years that the research in this area has been really strong, prompted by the BSE crisis, and we have a lot left to find out about even the basic functions of the prion protein.”



## Dr Gavin Stewart

*Lecturer – UCD School of Biology & Environmental Science*

# *Nitrogen - a new route to boosting gut bugs?*

Whether you are a cow, a sheep, a goat or a human, it pays to have a good relationship with the bacteria in your gut. So could we use nitrogen more smartly to broker intestinal harmony? Dr Gavin Stewart's research is investigating.

Animals produce nitrogen compounds as by-products of living. "Fish will produce ammonia, birds produce uric acid and mammals (including humans) produce urea, which makes up one of the major constituents of urine," explains Dr Stewart, who is a lecturer in comparative physiology at UCD School of Biology and Environmental Science.

But in ruminant mammals such as cows, sheep and goats, nitrogen can be 'recycled' and used by bacteria in the intestine, which can make use of the supposed waste.

"Ruminants recycle urea into the rumen and the bacteria have a urease enzyme which mammals don't possess, so the bacteria break down urea into ammonia and carbon dioxide and they can use the ammonia as nitrogen source for themselves," says Dr Stewart. "This means the bacteria are able to grow quite well, and the bacteria break down cellulose and produce short-chain fatty acids, which the animal can use as energy source."

This two-way relationship keeps both mammal and bacterium happy, and is one of the reasons that ruminants can survive on relatively low quality diet, according to Dr Stewart, who is exploring the dynamics of urea 'salvage' in the gut. "Our studies have shown that urea transporters are important in the gut of ruminants for moving urea across the gut wall to the bacteria," he says.

## Key research interests:

Urea Transporter

Human Colon

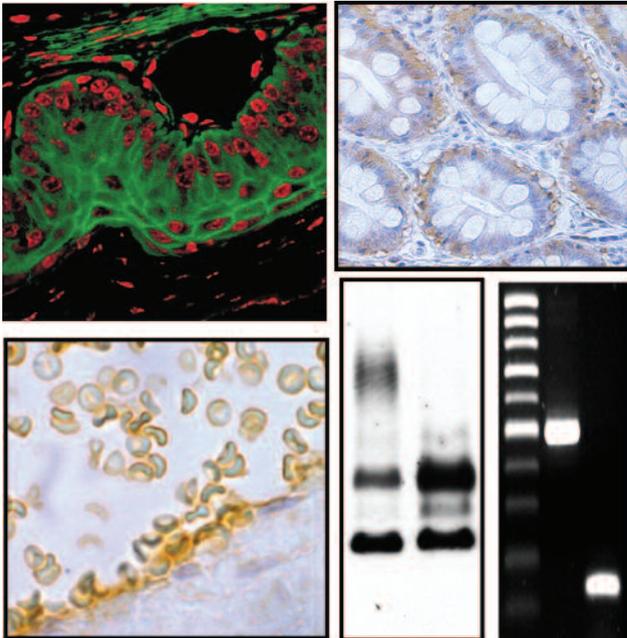
Cow Stomach

And now, with Professor Alan Baird from UCD School of Veterinary Medicine, he is looking at urea transport in the human intestine, where again a relationship with the resident bacteria can play an important role in general health.

“We are looking at where the urea transporters occur naturally in the gut, which will help us to better understand how humans may be using nitrogen to support the bacteria in our own guts,” says Dr Stewart.

The work could have applications in new approaches to influence the gut microbes, he explains.

“If you want to change the bacterial population in your gut, one way could be to overload it with an intake of new bacteria - maybe through oral supplements, which aren't always effective as the bacteria might not make it to the colon, or through enemas, which aren't convenient. Managing the nitrogen supply to bacteria in the gut could offer another route to controlling the microbes that live there.”



Images of urea transporter research -  
Image provided by Dr Gavin Stewart



## Dr Jana Haase

*Lecturer – UCD School of Biomolecular & Biomedical Science*

### *New insights into depression – gender diversity and links to inflammatory diseases*

Depression is a complex condition - men and women may manifest different behaviours when depressed, and people with inflammatory diseases such as rheumatoid arthritis, cancer and cardiovascular disease often experience depression alongside their ailment.

Dr Jana Haase has been getting glimpses into the molecular underpinnings that could help explain some of these more 'personalised' aspects of depression. Her main focus is on a protein called the serotonin transporter, or SERT, which regulates how efficient the neurotransmitter serotonin gets recycled back into brain cells after triggering signals in neighbouring cells.

"By regulating how much serotonin lingers in the space between brain cells and for how long, the transporter has quite an important function in mood," says Dr Haase, a Lecturer at UCD School of Biomolecular and Biomedical Science. "SERT is also a target for the most common antidepressants, the selective serotonin re-uptake inhibitors, and also MDMA, better known as ecstasy."

We have much yet to learn about SERT and its role in depression, and this has clinical implications, as Dr Haase explains. "Only about 30-40 per cent of people respond successfully to first-line treatment with the anti-depressants that target SERT, and it can take weeks for them to have an effect," she says.

To get a deeper insight into SERT and its function and regulation in the brain, Dr Haase has been looking at the proteins that interact with the transporter. Through a screening process, she identified some interesting proteins, and has brought those through to in vivo studies.

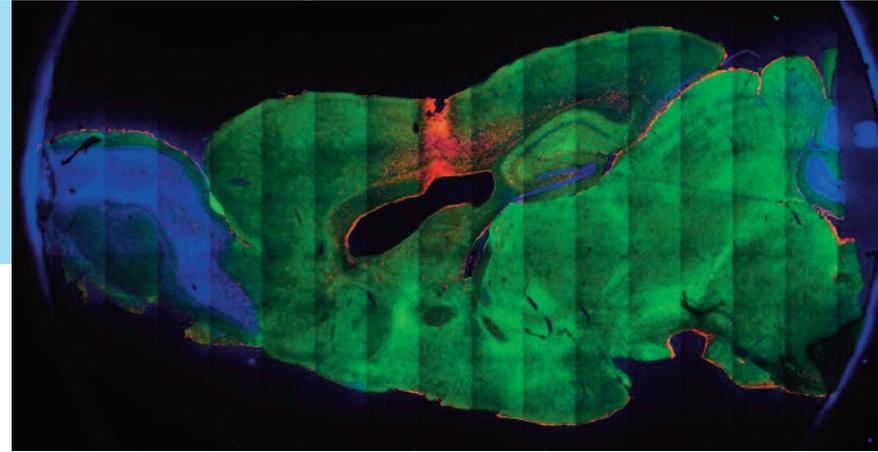
## Key research interests:

Neurochemistry  
Neurotransmission  
Membrane Transport  
Brain-Immune System interactions  
Depression  
Mood Disorders

While working with a model that lacks one of these key proteins, Dr Haase noticed a remarkable difference between the effects in male and females. "It was surprising, but it was striking," she recalls. "It looks like the genders have different mechanisms to reach the same levels of SERT activity."

While the research is at an early stage, the observation could tie in with gender-related differences in depression, she notes. "About twice as many women develop depression as do men, and we also know that symptoms of depression are different in women than men - women tend to have more feelings of guilt and worthlessness, while men tend to be more irritable. I think we may have uncovered something that could be a molecular contributor to the basis of this gender difference."

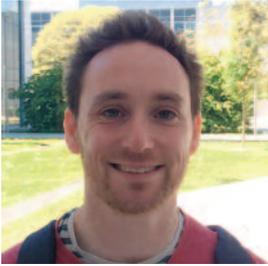
The observations add to a growing body of evidence that pre-clinical and clinical trials of depression treatments in humans need look at the effects of gender, according to Haase, who also suggests that males and females might even need different types of drugs to target depression.



Serotonin transporter (green) distribution in mouse brain -  
Image: Robert Schwamborn & Dimitri Scholz

She is now exploring links between depression, SERT and the chronic inflammation that underpins diseases such as cardiovascular disease, diabetes, rheumatoid arthritis and cancer. "We know that these inflammatory diseases are associated with a higher incidence of depression, and we are looking at how SERT is regulated in models of inflammation," she explains.

Dr Haase would like to see her research feed into a wider conversation about depression in inflammatory illness. "We need to be looking more actively at depression in these diseases, as it can have such an impact on quality of life."



## Dr James Sweeney

*Lecturer – UCD School of Mathematics & Statistics*

### *Statistical Modelling brings a more practical focus to cancer imaging*

Cancer has something of a sweet tooth: tumours have an enormous need for energy and tend to hog available sugars to fuel their growth. But this relative greed can also help doctors to find them - PET scans that pinpoint hotspots of sugar uptake in the body can highlight the locations and aggressiveness of tumours, explains Dr James Sweeney, a Lecturer in Statistics.

“In Positron Emission Tomography (PET), a glucose substrate laced with a radioactive isotope is injected into the body's bloodstream, and cancerous tissue hoards the glucose,” he says. “So if the patient is scanned in a PET medical imaging machine over a period of, say, 90 minutes, it is possible to infer (from the resulting series of medical images) regions of the body where cancerous growths are prevalent, and their vigour.”

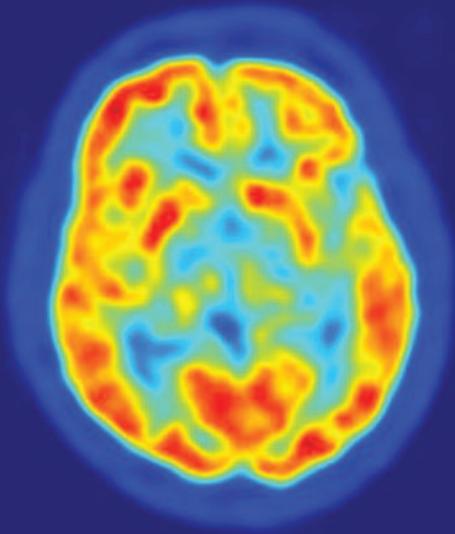
Such scans can help avoid extremely invasive procedures to remove benign lumps or tumours that are growing so slowly as to not register a threat, and which have little or no impact on quality of life, notes Dr Sweeney, but there are caveats.

“PET imaging itself can be invasive, as it needs samples of arterial blood which is a painful and invasive procedure for the patient,” he explains. “The patient also needs to lie stationary in a machine for around 90 minutes in order to get the required number of images.”

That’s why Dr Sweeney and clinical collaborators are looking to statistics to take the pain out of PET scans. Using statistical modelling techniques, he wants to bypass the need for an arterial blood sample. “Instead of taking invasive samples of arterial blood to assess glucose concentration, we can harness statistical tools to try to infer this from the medical images themselves, with the trade-off being increased uncertainty in our estimates of concentration,” he explains.

## Key research interests:

Data Analytics  
Medical Imaging  
Clustering  
Spatial Analysis  
Bayesian Statistics



PET- Image provided by Dr James Sweeney

He is also looking to speed up the scans, thereby reducing the 'lying still' time for each patient, and with the aim of cutting down on waiting times for scans.

"We are also trying to reduce the time it takes for each scan down to 15 minutes," he says. "At present, this results in a noisy series of images, which are of limited value. But, by incorporating prior information from past studies of large cohorts of patients and using Bayesian statistical methods, we can dramatically increase the value of these limited scans so as to nearly render them comparable to the full studies. This will have the benefit of hugely increasing the throughput of patients and better use of the machines themselves."

And interestingly, the underlying statistical methods that Dr Sweeney uses to improve medical imaging could also help us to fight fraud.

"For statistical analysis of medical images you need tools to deal with the huge volume of information provided by machines, so it is essentially a dimension reduction problem," he explains. "Similarly, in fraud detection, companies have huge volumes of information on client transactions and attempting to detect patterns and identify the important variables is an analogous task."



The background is an abstract composition of vibrant green and blue hues. It features several bright, glowing light streaks and curved lines that create a sense of motion and depth. The colors transition from a deep, dark green in the upper left to a lighter, more cyan-blue in the lower right. The overall effect is futuristic and dynamic.

UCD Science Showcase 3  
Environment



## Dr Tasman Crowe

*Senior Lecturer - UCD School of Biology & Environmental Science*

# *An ecological eye on oysters - reducing stresses and maximising benefits*

Oysters are a delicacy in demand, but farming them is not without its stresses. 'Invading' species can take hold at oyster farms, where they grow rapidly. Conversely, some types of farmed oyster can themselves 'escape' and cause problems in the wild.

Dr Tasman Crowe and his group at UCD School of Biology and Environmental Science are taking an ecological-eye view of these issues in oyster farming, with the aim of protecting oysters from the environment and of protecting the environment from oysters.

One of the prime targets in their sights is an aquatic animal species called *Didemnum*, which is well known in some parts of the world for 'invading' oyster farms, fouling up equipment with its slimy presence and choking oyster growth.

"In other parts of the world it has caused really big problems and there was major concern when it was found here in Ireland, but so far it has become established in just a few places," says Dr Crowe. "So in principal we might have an opportunity to reduce its spread at this early stage."

PhD candidate Martina O'Brien is currently testing protocols of techniques for warding off *Didemnum* - such as spraying vinegar or turning oyster bags - to see what combination works best for keeping oysters happy and the invasive species out.

"That project is trying to find out whether it is better to do one or the other or both, whether intensive or low doses are better, whether the techniques should be applied simultaneously or not and when during the growing season is the optimum," explains Dr Crowe. "And this is all derived from ecological theory about how disturbance regimes can have an impact."

## Key research interests:

Marine Biodiversity  
Ecosystem Functioning  
Ecosystem Services  
Human Impacts  
Multiple Stressors  
Invasive Species



Oyster Farm – Image provided by Dr Tasman Crowe and his research team

The work will hopefully inform practices in oyster farming in Ireland to help keep *Didemnum* out, but what about keeping the oysters in?

Already Dr Crowe's group has made some important discoveries about how to keep the Pacific oyster corralled into farms and not running riot in the wild. "It has become established in the wild in a lot of places in Europe, and when that happens it forms very dense beds and dramatically changes the local ecosystem, often with undesirable effects."

Dr Crowe's research has found that Pacific oysters are starting to get a foothold in the wild in Ireland too, and their recommendation is that farmed oysters here should be of a 'triploid' variety, a genetic variation that reduces the ability of the animals to reproduce and spread.

But it's not a clear-cut solution: some markets are not so keen on triploid oysters, and this feeds into Dr Crowe's wider research on 'ecosystem services' or, bluntly, the value of what nature can do for us. That might include fisheries from the marine, new pharmaceuticals from plants, services such as cycles that regulate climate and supply water and the cultural benefits we enjoy.

"The value of nature has become part of the rationale for conservation," he explains. "So we are trying to better understand benefits from nature and how to value and conserve them."



## Dr Aggeliki Georgiopoulou

*Lecturer – UCD School of Earth Sciences*

### *A new take on the ‘personalities’ of landslides at sea*

Landslides can sweep away all in their path. On land this might mean people, cars, trees and buildings, so we pay attention to them, but what about the landslides that happen under the sea?

These dramatic submarine events can wreak havoc in the ocean, but they can also affect coastal regions by triggering tsunamis - so we need to understand how and when they might happen, according to Dr Aggie Georgiopoulou, a Lecturer in Sedimentology at UCD School of Earth Sciences.

As well as wiping out marine life in the affected area, the impact of submarine landslides can ripple further afield if they result in large volumes of water hitting land, so Dr Georgiopoulou is analysing the characteristics and ‘personalities’ of historical landslides to find out what are the likely triggers and get a sense of whether it is likely to happen again.

“I find out why they happened where they happened and if landslides happen frequently at a location, what is the repetition interval,” she explains. “By finding out that information we can better understand the risks in a region, both for monitoring seismic activity in the area so warnings can be issued if needed, and also for planning new constructions: you don’t want to build a jetty or a coastal road close to a site where a landslide could be triggered by the building activity.”

By their very nature and locations, marine landslides tend to be hard for humans to access, so Dr Georgiopoulou uses data captured with acoustic waves, images taken with a remotely operated submarine vehicle and physical cores of sediment sampled from these ancient marine landslide sites to work out what happened.

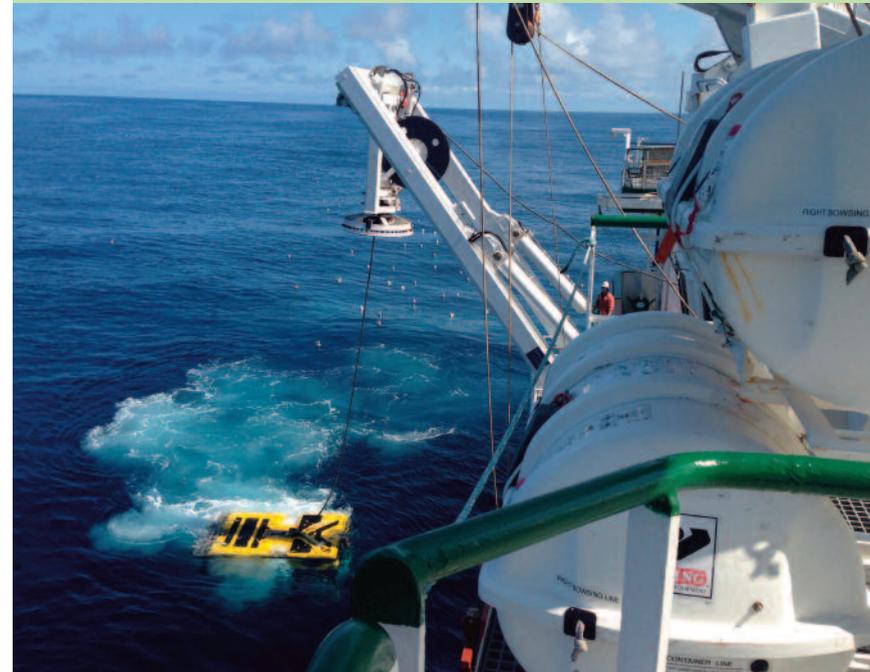
Her work has seen her trawl through data from landslide hotspots such as the Canary Islands, the Mediterranean and the Rockall Trough about 430 km off the north-west coast of Ireland.

The Rockall work is modelling existing deposits from submarine landslides there, teasing out the multiple events that appear to have taken place in the past and figuring out whether the volume of sediment in those previous events could have been sufficient to trigger a tsunami.

“We need to work out the frequency of these landslides and why they happened, says Dr Georgiopoulou. “The ‘why’ is critical - if it has got nothing to do with what is going on currently in the physical environment then maybe we don’t need to worry. Either way, we want to feed our findings into warning systems for the Atlantic as a low, medium or high risk will need to be assigned.”

## Key research interests:

- Submarine Landslides
- Tsunamis
- Submarine Canyons
- Marine Geohazards
- Seafloor Morphology
- Oceanography



German research vessel RV Poseidon – Image provided by Dr Aggeliki Georgiopoulou



## Dr Jens Carlsson

*Lecturer - UCD School of Biology & Environmental Science*

### *The ecology of 'genetics for the masses'*

Keeping track of animal populations is an important task when monitoring the environment. Knowing whether populations of wild animals are robust or if they are teetering on the brink of disaster can help us better manage and protect them. But head counts are arduous and don't always give the best indication of how populations are faring, and tracking individual animals is costly and often unfeasible. Could clues from DNA offer more insights?

Dr Jens Carlsson and his group at the UCD School of Biology and Environmental Science think so - and they are developing less costly and faster ways of analysing that DNA for ecological information.

"We are interested in populations and their health status, how they are connected and their sizes," he explains. "And we are developing a range of tools to get that information using genetic methods."

Based on DNA sampled from animals in the wild, Dr Carlsson's research is building a dynamic view of how populations change over time. To carry out the analysis, his group has developed a next-generation sequencing approach they call 'Genetics for the Masses'.

"It allows us to carry out analysis much faster than before - a study that before might have taken 36 man-months, we can now do in two man-months," he says. "And our approach also brings the cost of the analysis down dramatically."

## Key research interests:

Next Generation Sequencing  
Genotyping by Sequencing  
Conservation Genetics  
Fisheries  
Hydrothermal Vents

Cold Seeps  
Chemosynthetic  
Environmental DNA  
Aquatic



[https://commons.wikimedia.org/wiki/File:Large\\_fish\\_school.png](https://commons.wikimedia.org/wiki/File:Large_fish_school.png)

Much of their genetic work to date has been on fish stocks, to understand how populations of fish are growing, moving and mixing, and if they are vulnerable to damage from overfishing.

"One end goal is to have a real-time fisheries management based on biology," explains Dr Carlsson. "You may have mackerel or boarfish in Iceland and Ireland, and we want to see how they fluctuate over the year when they start to mix and when they break up. That would allow you to tell that one population is big and can withstand fishing, but another population can't, and when they meet we cannot fish them."

Dr Carlsson's group is also using other genetic tools to find clues about populations by using the traces of DNA they leave behind in the environment. They are

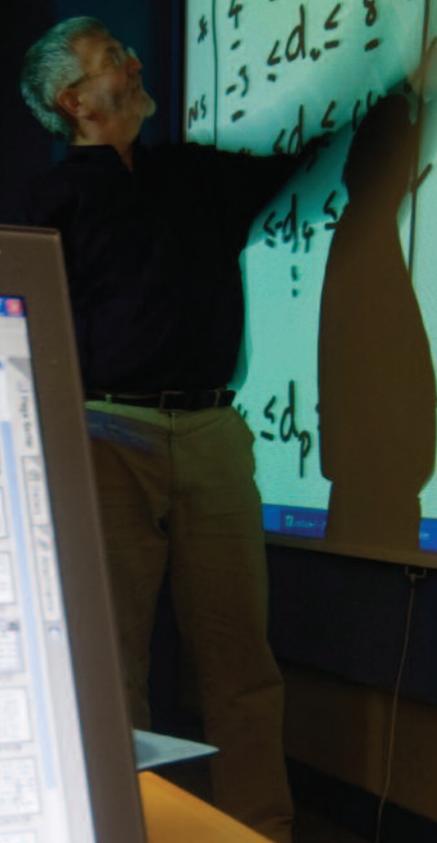
looking at environmental or 'eDNA' in seawater to track the sizes of fish stocks and also the peculiar organisms that live in deep-sea hydrothermal vents and methane seeps.

As well as gleaning genetic clues from the sea, Dr Carlsson is now bringing the Genetics for the Masses and eDNA technology to Kenya, where it could be used to track wild animal populations that might otherwise be inaccessible.

"We want to look at the DNA in watering holes, to see which animals have been using them," he says. "And you can also use DNA from droppings to assess population structure and better understand how to protect these animals."

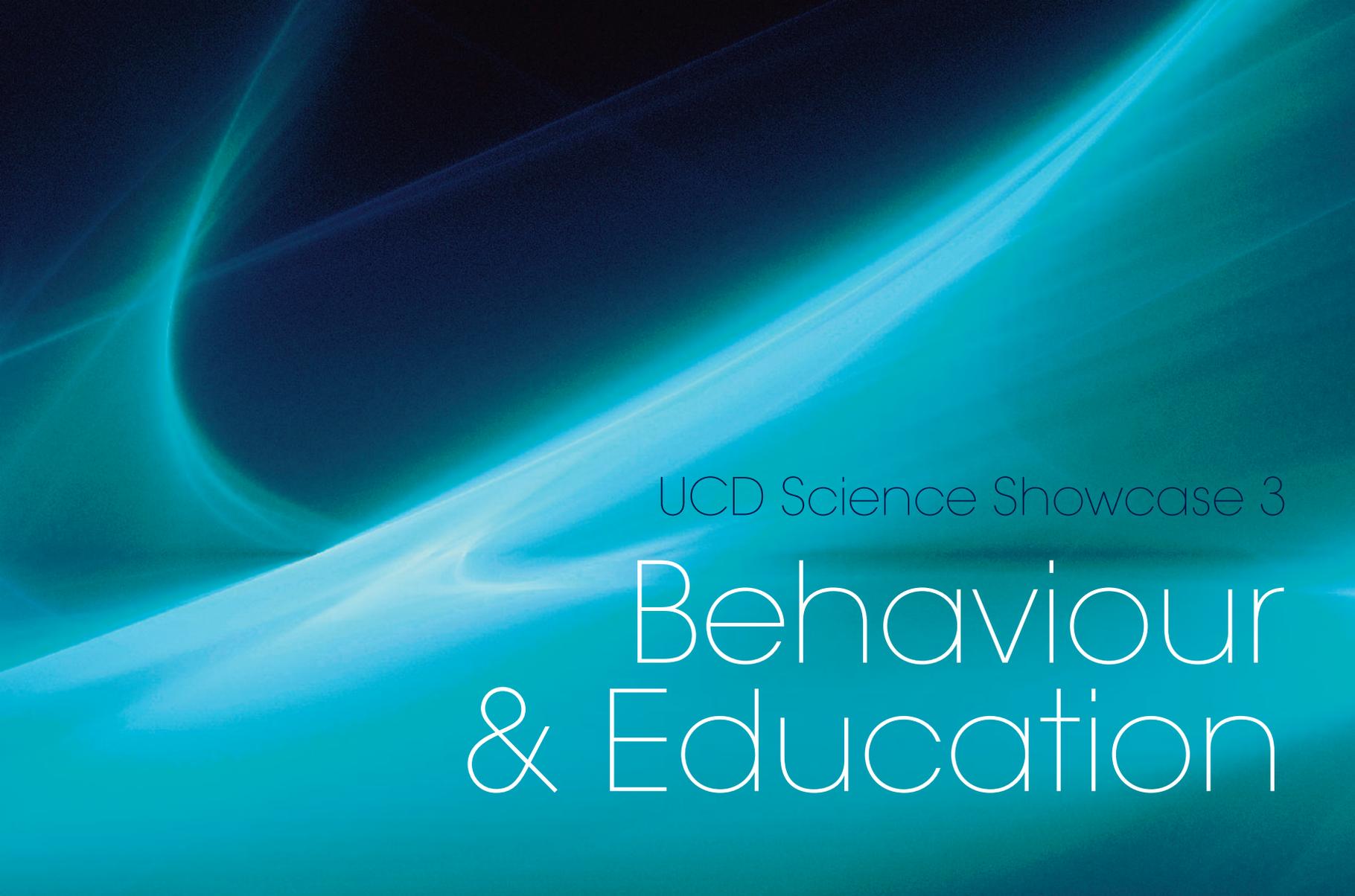
*	$4 \leq d_1 \leq 10$	observed difference Vector
NS	$-3 \leq d_2 \leq 8$	
x	$8 \leq d_3 \leq 14$	
x	$-10 \leq -d_4 \leq -4$	
*	$18 \leq d_p \leq 25$	

$H_0: d_1 = 0$   
 $H_0: d_2 = 0$   
 $H_0: d_4 = 0$   
 $H_0: d_p = 0$



Vector

$H_0: d_1 = 0$   
 $H_0: d_2 = 0$   
 $H_0: d_4 = 0$   
 $H_0: d_p = 0$

The background is an abstract composition of blue and teal colors. It features several bright, glowing light streaks and curves that sweep across the frame, creating a sense of motion and depth. The colors transition from a deep, dark blue on the left to a lighter, vibrant teal on the right.

UCD Science Showcase 3

# Behaviour & Education



## Dr Vladimir Lobaskin

Lecturer – UCD School of Physics

# *A flock of humans? How physics models of nature can offer insights into societal behaviours*

Have you ever watched as a flock of birds flies overhead? The individuals seem to self-organise as they collectively soar, swoop and suddenly change direction.

Similarly, groups of fish and insects seem to work as a dynamic whole. Could there be parallels with how humans think as a collective?

Dr Vladimir Lobaskin from UCD School of Physics has been looking at the parallels between how individual animals or particles interact in nature, and how opinions and behaviours spread through human societies.

Flocks of animals in nature form fascinating structures, explains Dr Lobaskin, who describes each individual's direction of motion as a 'vector' for the mathematical model.

*"We were inspired by similarity of flocking to ferromagnetism - the animal behaviour resembles the way the elementary atomic magnets interact with their neighbours to align the vectors and 'negotiate' the common orientation in space."*

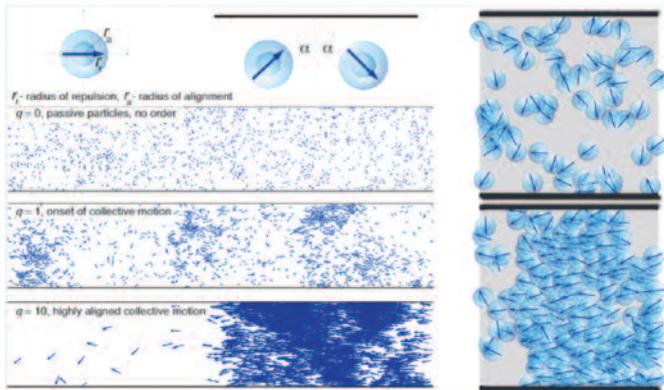
Could these local interactions influence the entire crowd? By modelling such interactions, Dr Lobaskin and colleagues have found that these neighbourly alignments may provide enough impetus for the overall group to self-organise - even without any central co-ordination or specific common purpose.

"We see that if you have a sufficiently large pool of agents and the agents only talk to their neighbours, this is sufficient to cause global ordering independently of the nature of the interactions or the nature of the motion," he explains.

## Key research interests:

Soft Matter  
Computer Simulation  
Nanomaterials  
Biological Physics  
Collective Behaviour

Flocks can spontaneously scatter into distinct subgroups, so Dr Lobaskin and colleagues looked at how their physics models of this fragmentation in nature could apply to human opinions in society.



Particles – Image provided by Dr Vladimir Lobaskin

“If you think of the model as being of human opinions, we can envision a situation when only like-minded opinions interact,” he explains. “And when the society is made of such narrow-minded individuals who are only prepared to listen to people from their circle, we see that it spontaneously splits into opposing groups.”

Dr Lobaskin likens this polarisation to divisive splits seen in politics and wars, where groups stop listening to one another and the divisions become more deeply entrenched. And, just as in nature, the energy supply is critical. “If you show people graphic images and cause them to feel anger, anxiety and fear, that supply of emotional energy may become over-critical and you see this self-organisation into distinct groups,” he says.

The physical model also hints at what is needed to avoid such polarisation in societies: open-mindedness, a diversity of information and points of view and a lack of social pressure to conform with one group or another are key, he notes.

Dr Lobaskin and colleagues are starting to collaborate with researchers beyond physics to see how the modelling approach could inform our understanding of collective behaviour in human societies. “These effects have been described in sociology for many years,” he says. “And now we are looking at it with physics, we see that the phenomena are more general in nature than we might have thought.”



## Dr Tadhg O'Croinin

*Lecturer – UCD School of Biomolecular & Biomedical Science*

### *Study Abroad students get a taste of research life at UCD*

When science students in UCD get to their final year, they generally get the opportunity to flex their muscles in the lab: for several months they immerse themselves in a project and get a feel for research life. But until recently, research was out of reach for international students spending time at UCD on the Study Abroad programme.

That has all changed thanks to the Introduction to Research module that sees overseas students spend several hours each week working closely with a UCD research group on a subject of their choice.

“At UCD we have a long history of students coming to study here for a semester in their second or third year of university, but it would be predominantly in the arts,” explains Dr Tadhg Ó Cróinín, who is

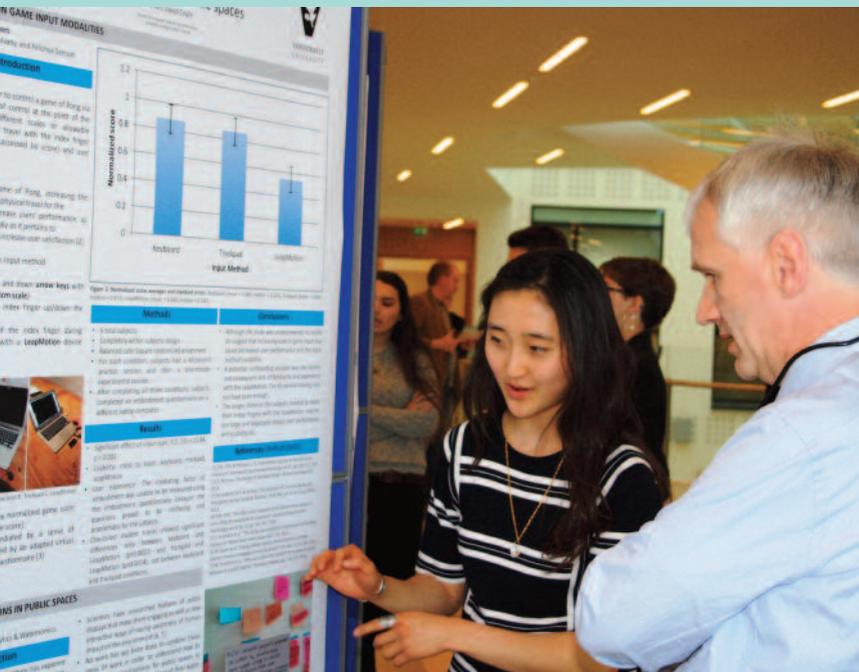
Associate Dean for Study Abroad at UCD. “So we have been working to make UCD science modules more attractive to them.”

One of UCD’s strengths in science is its research, notes Dr Ó Cróinín, so the Introduction to Research module looks to give the Study Abroad students a chance to engage with internationally acclaimed principal investigators and their research teams in UCD. “We devised this module that would allow them to come into the lab for seven to eight hours a week and work on a project with a post-graduate student,” he says. “They are immersed in a research group.”

So far, Study Abroad students have worked in geology, computer science, pharmacology, neuroscience, zoology, chemistry, microbiology, physics and environmental and plant biology.

## Key research interests:

International STEM Education  
Infection Biology  
Host Pathogen Interactions  
Bacterial Gene Regulation  
DNA Supercoiling



Study Abroad student discussing her work and scientific poster with an academic audience at UCD Science mini-conference in the UCD O'Brien Centre for Science – Image © UCD Science

“We have a huge diversity of projects, it’s really only limited by whether there’s a research group in UCD working in the area,” says Dr Ó Cróinín. “We have had students working with Dr Kevin O’Connor’s lab on Lactobacilli, which are hugely important in industrial microbiology, working with Prof John Walsh on software that analyses seismic faults and in my lab looking at *Campylobacter jejuni* bacteria that cause food poisoning.”

The students keep learning journals that they share with their peers, and ultimately they present their scientific findings in poster format at a mini-conference. “We want to make sure they get the full concept of what it is like to produce your work and be able to defend it and talk about what you would do next,” says Dr Ó Cróinín.

The number of students taking the module has doubled since it started in 2012, and participants come from a range of ‘home’ institutes in the US and beyond, including Notre Dame, George Washington University, North Eastern University, St Mary’s College Maryland and the Universidade de São Paulo.

The module can also strengthen international ties, explains Dr Ó Cróinín. “We send the students’ posters back to the home institutes,” he says. “And if that poster is hanging on the wall in Notre Dame it can start building more research collaborations and increase UCD links with other universities.”

# UCD Science Schools

## **UCD School of Biology & Environmental Science**

The UCD School of Biology and Environmental Science is the largest teaching and research centre for biology in Ireland. A unique feature of the School is the inter-disciplinary nature of its activities, providing students and scientists alike with critical knowledge and perspective about modern biology, encompassing molecules through to ecosystems. At national level the School provides expertise that informs environmental and sustainable management policies, supporting the agricultural, food and biomedical industries.

The School's broad portfolio of teaching at undergraduate and graduate level is strongly informed by its research which is inter-disciplinary in nature and covers ecosystems, global change and sustainability; evolution and population biology; plant sciences; and cellular systems.

## **UCD School of Biomolecular & Biomedical Science**

The School plays a major role in one of the most rapidly advancing areas of science today, the field of biomolecular and biomedical research and its impact on our understanding of health and disease in all forms of life. These research fields underpin key industries with substantial presence in Ireland, for example Ireland is home to 9 of the top 10 global pharmaceutical and biotechnology companies.

The diversity of expertise within the School is a major facilitator for interdisciplinary teaching, scholarship and research and provides a unique forum to investigate biological systems at molecular, cellular and whole organism levels. The School focuses on three key areas of biomolecular research: Infection Biology, Biotechnology and Disease Mechanisms, which comprise neuroscience, cardiovascular disease, diabetes and cancer.

## **UCD School of Chemistry**

With seven of the 10 global blockbuster pharmaceuticals being made in Ireland by pharmaceutical and biotechnology companies such as Glaxo SmithKline, Pfizer, Merck, Bristol Myer Squibb and Genzyme, the UCD School of Chemistry is in a unique position to support this major industry. Ranging from educating future scientists and leaders to providing a superb research environment with world leading research groups and facilities which address a wide variety of research topics, the School supports industry, government and academia throughout the world. Research activities span the core disciplines of organic, inorganic, and physical chemistry and the interdisciplinary frontiers of the life and physical sciences.

## **UCD School of Computer Science**

Ireland is home to the world's top 10 technology companies. It is known as the Internet and Games Capital of Europe and is among the world's most technologically developed nations. The UCD School of Computer Science has an established record in scholarship and research in this thriving sector. The School delivers innovative programme structures including 'negotiated learning' – allowing students to combine learning modules best-suited to their chosen path within the booming ICT industry.

### UCD School of Earth Sciences

The School of Earth Sciences is the largest Geoscience school in Ireland offering degree programmes that reflect the needs of society and industry, producing graduates who are nationally and internationally highly regarded. Along with a BSc in Geology UCD offers PhD and MSc by research. The MSc in Petroleum Geoscience, a 1 year taught masters degree, is a collaborative initiative with Tullow Oil PLC and the only one of its kind in Ireland. The School has an internationally recognised reputation for research, covering the broad spectrum of specialities with a seamless transition between pure and applied research in the areas of fault analysis, geochronology, petrology and isotope geochemistry, geophysics, marine and petroleum geology, palaeobiology and palaeoclimatology. Research funding typically exceeds €2 million per year, with research projects currently supported by more than 13 international petroleum companies.

### UCD School of Mathematics and Statistics

UCD School of Mathematics and Statistics is ranked in the top 200 in the world for both the subjects of Mathematics and Statistics (in the QS World University Rankings by Subject 2015). The School is the largest of its kind in Ireland and offers the greatest choice of programmes at undergraduate, masters and PhD level, reflecting the ubiquity of the mathematical sciences in the modern world. As a dynamic, multi-disciplinary school, UCD Mathematics and Statistics engages in research and teaching in three disciplines: Applied and Computational Mathematics, Mathematics, and Statistics and Actuarial Science. Academic staff are actively involved in many research centres and institutes including Insight Centre for Data Analytics, UCD Complex and Adaptive Systems Laboratory, UCD Meteorology and Climate Centre, the Earth Institute and Claude Shannon Institute.



### UCD School of Physics

Across Ireland, physics-based businesses contribute more than €7bn to the economy and directly employ over 86,000. As part of its activities, the School provides the graduates and research to support these industries both in Ireland and globally. The impact of the School's research, as measured using bibliometrics, is 1.7 times the global average. This is delivered by a dynamic, international group of researchers working across a wide range of disciplines within Physics. These include: Astrophysics, Atomic, Molecular and Laser Plasma Physics, Condensed Matter Theory, Computational Biophysics, Experimental NanoScience, Experimental Particle Physics and Radiation/Medical Physics. The school is currently developing a research strategy to focus on Fundamental Physics and on Physics in Health and medicine.

## Dr Claire O'Connell

Dr Claire O'Connell is a science writer and journalist. She studied science at University College Dublin, starting her undergraduate degree in 1988. She specialised in Botany and then went on to do a PhD in UCD with Professor Finian Martin in the Department of Pharmacology, studying gene expression and morphology in mammary gland development.

In the late 1990s she did post-doctoral research at the University of Glasgow (fruit flies) and the University of Sydney (human brain pathology) before leaving the lab and working in e-learning for several years.

She switched to journalism and has been contributing to The Irish Times and other outlets for more than seven years. She also holds a Masters in Science Communication from Dublin City University.

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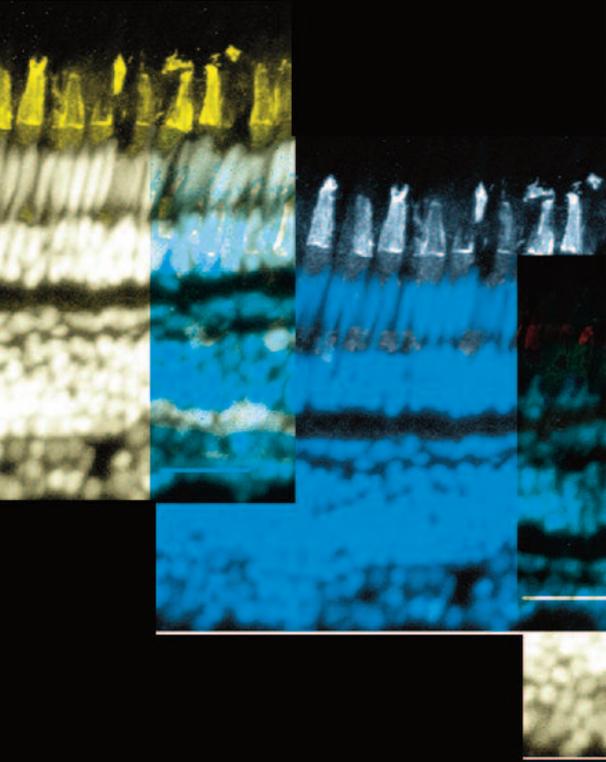
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## Contacts

UCD Science education information: [science@ucd.ie](mailto:science@ucd.ie)

UCD Science contact for alumni, industry and sector agencies:  
[science.relations@ucd.ie](mailto:science.relations@ucd.ie)



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