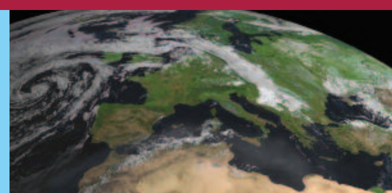
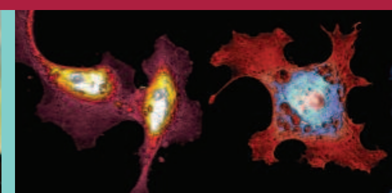
UCD SCIENCE SHOWCASE





VOLUME 2

Welcome

I am very pleased to introduce Volume 2 of our UCD Science Showcase. The purpose of this publication is to share highlights of recent 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 & Chemical Biology, Computer Science & Informatics, Geological Sciences, Mathematical Sciences 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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Earth & Discovery

Dr Sheila McBreen

Lecturer, UCD School of Physics

On call for the Universe

Doctors, vets and rescue workers are often on call for emergencies, keeping an ear out for the alert that they are needed. But how about being on call for the Universe? Dr Sheila McBreen's work tracking massive 'gamma-ray bursts' from distant galaxies can mean dropping everything at a moment's notice, day or night, to follow an event.

"When a massive star goes supernova there's a huge explosion," explains Dr McBreen, who is a Lecturer at UCD School of Physics. "And from that explosion you might get a gamma ray burst on the order of minutes long."

The gamma rays can travel relatively unimpeded across the universe, and the intensity of the burst means it can highlight a distant galaxy for that short period, so it's important to detect and pinpoint the burst as quickly as possible.

That's why Dr McBreen is part of a global response network that jumps into action when gamma-ray satellites orbiting the Earth detect a potential burst. "The satellite sends information to Earth, and then it is our job to try and find out where the rays are coming from and the kinds of galaxies they were in," she says.

Dr McBreen and her postgraduate students at UCD are 'burst advocates' with a European team based at the Max Planck Institute for Extraterrestrial Physics in Germany, which tracks data from the NASA Fermi satellite - they work in shifts with advocates in the USA to ensure someone is available around the clock.

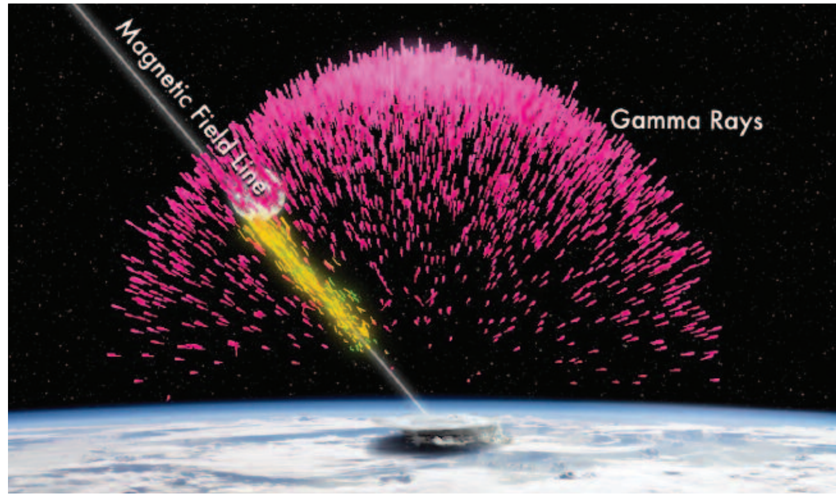
Each year Fermi registers around 250 gamma ray bursts, and when one comes in, the on-call burst advocate analyses the data and sends a report to others around the world who may be able to quickly follow up with telescopes and other instruments and gather more information about the event. "It's exciting, you don't know what is going to happen and you are often up at midnight trying to remotely point a telescope," says Dr McBreen.

As well as being on call for active events, her ongoing research analyses the data captured from interesting bursts to work out the distances the rays have travelled and to analyse the chemical signatures of these exploded stars. "Overall in the field we look to put these pieces of information together from as many bursts as possible and get a better overall picture of other galaxies," she explains.

Closer to home, Dr McBreen is also looking at extremely rapid gamma ray flashes produced by lightning on Earth, which were initially reported by Fermi team scientist Dr Jerry Fishman. And there's hopefully plenty more to come - along with Professor Lorraine Hanlon at UCD, Dr McBreen is working on European Space Agency funded research to develop technology for the next generation of detectors: "As well as working on our science today, we are also work on something for the future."

Key research interests:

High-energy astrophysics
Earth observation
Lightning
Detector development



Professor Peter Lynch

Professor of Meteorology, UCD School of Mathematical Sciences

A brighter forecast for maths

Rain or shine, the weather has an impact on our everyday lives, and many of us listen keenly to the forecasts after news bulletins. But did you know that maths plays a central role in figuring out whether we are going to need wellies or sunglasses in the days to come? Today we can predict weather patterns reasonably well four or five days ahead, but it wasn't always so, explains Professor Peter Lynch, Professor of Meteorology at UCD School of Mathematical Sciences. When he started work as a forecaster with Met Éireann in Shannon Airport almost four decades ago, even the one-day forecast was a bit dubious, he explains.

"Forecasting at the time was pretty awful," he recalls. "So the way forward was to use mathematical methods to model the atmosphere. And Met Éireann was starting off with computer forecasting - that was a rapidly developing area and there were a lot of interesting scientific challenges."

The field has since earned some bragging rights, according to Professor Lynch, because weather forecasting skill has improved - though there are still some challenges, particularly around rainfall. "Everybody wants to know if it's going to be a dry day for the match next Sunday, it's still hard to answer that," he says.

More recently, Professor Lynch has been looking to improve local wind forecasts, which are of particular interest for wind farms. "A wind farm is at a specific location, it might be on the side of a hill and the local topography is going to affect the flow strongly," he says. So Professor Lynch, Dr Conor Sweeney and PhD student Jennifer Courtney want to improve the accuracy of prediction with more appropriate statistical approaches, and it stands to help wind farm managers plan how to use resources, he explains. "The energy goes up as the cube of the wind speed, so a very small change in wind speed can make a big difference in available energy - and even if it's bad news and there is no wind tomorrow, you want to know that rather than hope in vain."

Key research interests:

Meteorology
Climate change
Weather forecasting
Atmospheric modelling

Hurricane Frances

Getting a handle on the future is also important in the bid to address climate change, and again mathematical modelling can help to anticipate what is going to happen at various scales. Professor Lynch is working with Dr Paul Nolan, a computational scientist at Ireland's High-Performance Computing Centre (ICHEC), to analyse regional patterns in Ireland, particularly of extreme rainfall.

In addition to his research and teaching in meteorology, Professor Lynch has recently moved into the area of popularising maths with his blog (thatsmaths.com) and with regular columns in The Irish Times on the first and third Thursday of each month.

"I have always had a deep passion for mathematics, it's really the love of my life - it's not only useful but it's also beautiful and it's great fun as well," says Professor Lynch. "I try to stress in the column all the practical applications, basically why is maths important, and I think if a few young people read the columns and get an interest, then it's worthwhile."

Dr Andrew Parnell

Lecturer, UCD School of Mathematical Sciences

Bringing certainty to an uncertain world

Few things in life are certain. Yet we rely on accurate information to cope with climate change or to predict the course of a disease. That's why Dr Andrew Parnell is using statistics to get a better handle on uncertainty, particularly in understanding climate change and cancer, and he is getting some startling results.

"We are building methods that not only give you accuracy but also the power of how certain the results are," explains Dr Parnell, who is a Lecturer in statistics at UCD School of Mathematical Sciences. "We build uncertainty into everything we are doing."

Many scientists, when presented with uncertain data, draw a straight line of best fit - yet many patterns in nature are non-linear and climate is a case in point, says Dr Parnell, who is analysing data about sea level change across recent centuries.

"People have often assumed a linear increase, but sea level doesn't change in a nice straight line and the measurements themselves may not always have been accurate," he says. "And when we use our statistical models, we see recent rates are more rapid than many have assumed - it is scary."

Dr Parnell is also looking further back in history at how rapidly climate warmed after the last major glaciation ended around 20,000 years ago. He is analysing levels of pollen and other material in sediment cores drilled from lake beds.

Key research interests:

Big data

Statistical Modelling

Feature Selection

Machine Learning

Bayesian Statistics

"Plants can act like thermometers - when it's warmer certain types of pollen get released and laid down in these cores, but it's not exactly in step with temperature, and also humans may have disrupted environments," he explains. "So we are using mathematical methods to take that uncertainty into account and trying to work out the actual speed of climate change."

As well as looking back, Dr Parnell is also looking to the future of climate change. He has just started working with Dr Conor Sweeney and with Met Éireann on data from weather stations in Ireland over the last 60 years: "We are trying to work out how extremes of temperature and rainfall and wind have changed, how that maps on to climate data and what we can expect into the future as the climate changes."

It might seem like a non-sequitur, but another strand of Dr Parnell's work applies statistical methods to pick out signals of proteins in blood samples that are linked with more aggressive forms of prostate cancer. Working with Professor Steve Pennington, he has developed a new statistical tool to analyse potential 'biomarkers' that could ultimately help doctors decide the most appropriate treatment for patients.

"Prostate cancer and climatology do sound like different areas," admits Dr Parnell. "But you can use similar mathematical tools - in climatology you are trying to work out which types of pollen are important for telling you about climate change and in the prostate you are working out which proteins are important to tell you about the cancer changes."

Dr Miguel D. Bustamante

Senior Lecturer, UCD School of Mathematical Sciences

The maths of going to extremes

Large earthquakes and devastating hurricanes are thankfully relatively rare events. But understanding more about the maths behind such extreme events could help to improve how we can predict them - and it may even help with the more mundane weather forecast too. Dr Miguel D. Bustamante is looking at the maths behind low-probability events using the model of colliding vortices in fluids such as air and water, and the work feeds into the wider field of 'extreme events', as he explains.

"Mathematically speaking there are situations where you can define extreme events like rogue waves or freak waves, or tsunamis, hurricanes - and they have to do with events which have a small probability to occur," he says. "Hurricanes have a small probability and big earthquakes have a small probability, and it is possible to put them under the same umbrella."

Extreme events can appear because systems are not linear, explains Dr Bustamante, who is a Senior Lecturer at UCD School of Mathematical Sciences. "You start with smooth initial conditions and then the behaviours are not simple, it leads to turbulence," he says. "So we have been studying the dynamics of a turbulent system - vortices colliding in a fluid - as a model."

Key research interests:

Energy Transfers in Nonlinear Wave Systems

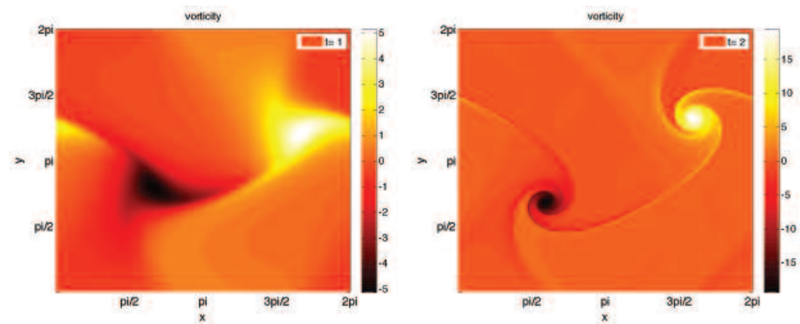
Fluid Mechanics and Extreme Events

Industrial Mathematics

By numerically simulating how these vortices collide and react and by looking to predict 'singularity' where the object can no longer be mathematically defined, it's possible to analyse physics that would be too impractical or costly to access with experiments, he notes.

"Understanding the singularity is important - if you can predict when one is coming then you would be able to understand an extreme event is coming."

Through his work on the vortex model, Dr Bustamante has now presented a new way to mathematically look at the singularity problem: he reformed co-ordinates to look at the velocity field divided by the maximum vorticity and found that this simplified the equations needed. He is now working on implementing numerical simulations of these equations in two and three dimensions, and he hopes the work will enable more capable computer programmes predicting extreme events without the need for more computing power.



Vortex models. The concept of singularity was also dramatised in the short film 'Singularity Day' http://www.youtube.com/watch?v=UdutmuiiVFQ&feature=youtu.be

"You just need to write a new code in the mapped co-ordinates and you would gain a lot in precision," says Dr Bustamante, whose research is funded through Science Foundation Ireland, and describes how the underlying approach could ultimately be used to help inform analyses of weather, climate, earthquakes and volcanoes: "It means improving the prediction power at the same time as computing costs - that would be the promise we hope."

Professor John Walsh

Professor, UCD School of Geological Sciences

Precise to a fault - mapping conduits to underground resources

Terra firma - we refer to it as a reassuring place to be, but in truth some parts of the Earth's surface are anything but stable. Pressure builds up in the outer layers of rock that envelope the planet, and when it releases, the resulting cracks, or faults, displace layers of that rock.

The immediate effect can be an earthquake, explains Professor John Walsh, Joint Director of the Fault Analysis Group at UCD School of Geological Sciences, but in the longer term faults can also offer conduits for precious underground resources - such as minerals, water and oil - to rise up closer to the Earth's surface.

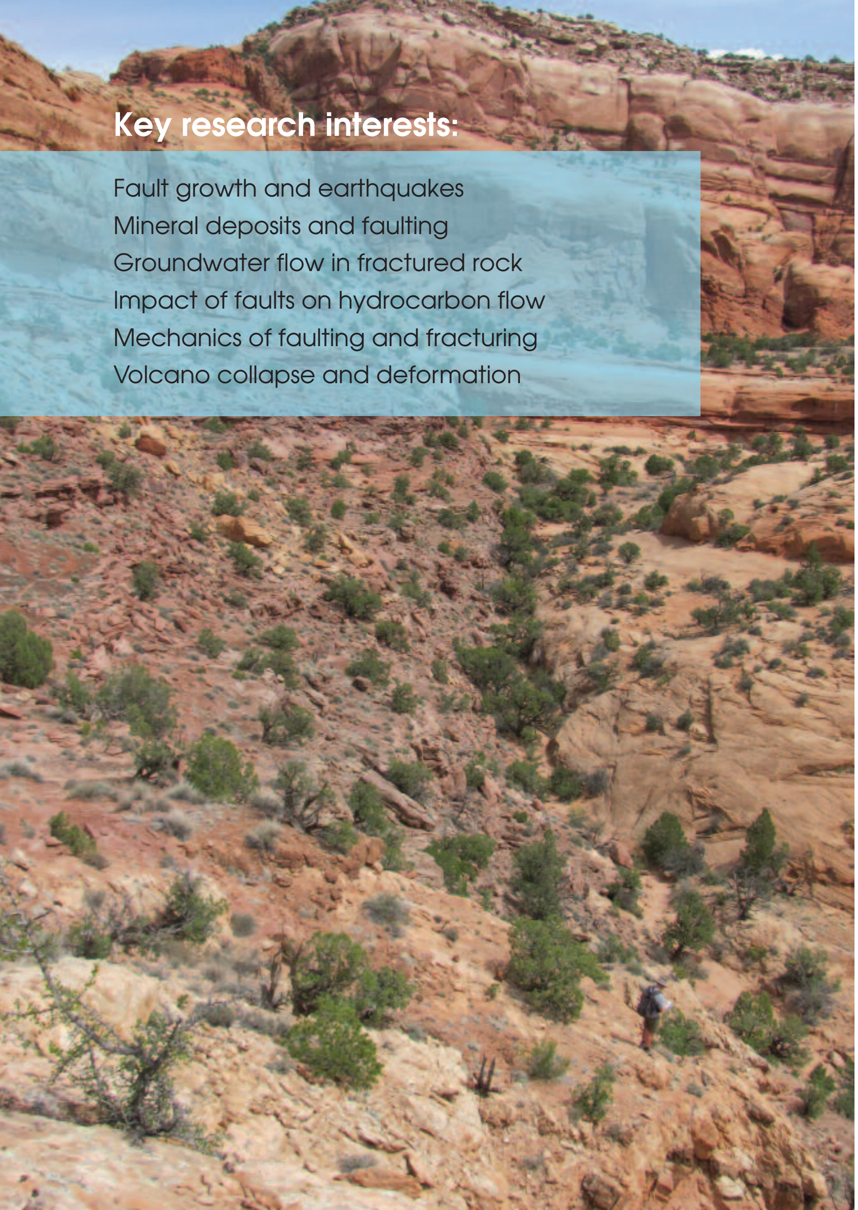
"A lot of oil is contained within particularly porous rocks, and those in turn are covered in another layer of rock which prevents the oil escaping upwards," he says. "If you have a fault which offsets those layers it can either make it more complicated to access the oil or it can be a good thing, with the faults themselves acting as a trap to the oil."

Knowing more about faults can help mining and drilling companies to tap into underground resources. "We are fortunate in the sense that faults are both interesting academically and commercially," says Professor Walsh. "And that means we can do fundamental and applied research at the same time."

At present several companies fund the group's work, including Tullow Oil, which makes a 'significant contribution' to the School through supporting staff and research positions, explains Professor Walsh.

Key research interests:

- Fault growth and earthquakes
- Mineral deposits and faulting
- Groundwater flow in fractured rock
- Impact of faults on hydrocarbon flow
- Mechanics of faulting and fracturing
- Volcano collapse and deformation



Study area: Moab, Utah, USA

The UCD researchers have developed computer-based methods to predict the flow of fluids through faults under the Earth's surface, and companies are using the software to build up a better picture of faults in areas of potential interest. In 2010, the group received the 2010 NovaUCD Innovation Award in recognition of its successful commercialisation activities and its strategic and collaborative research links with global industry partners.

So how are they building on that success? The mission is to continue studying the best fault datasets and thus improve the analytical software, and the team is travelling the globe in search of exemplary faults, explains Professor Walsh.

"We analyse these faults in detail, their geometries and the nature of how they offset the layers," he says. "This is giving us more constraints on what faults actually look like so we can better predict what's happening in the subsurface and how it's going to impact either flow of groundwater or petroleum or the geometries of mineral or coal deposits. It's about improving your predictive capability so you can find or extract resources under the ground more effectively."

Dr Patrick Orr

Senior Lecturer, UCD School of Geological Sciences

Fleshing out the details of animal evolution

Imagine, just for a moment, that you had X-ray vision and you saw everyone as just their skeleton and teeth. How much detail would you be missing about their flesh, their hair and their colouring?

In the same way, much of what we see of animals in the fossil record is the hard stuff: the bones, teeth and shells. That can tell us something about the animals they came from, but if we knew about the softer materials - not to mention the entirely soft-bodied animals that lack a skeleton or shell - we could learn so much more.

Dr Patrick Orr from UCD School of Geological Sciences looks for those unusual instances when the flesh, marrow or feathers of an animal have been preserved for millions of years.

"We work with exceptional fossils, where the soft tissue that would normally decay very rapidly after the animal's death is preserved instead," he explains. "We ask what these tissues can tell us about the animal, and also why the tissue was so well preserved."

The researchers use electron microscopy to take a close look at these 'softer' fossils, and their findings are offering new perspectives. For one, it appears that some dinosaurs had pretty flamboyant colour schemes. Dr Orr and colleagues analysed pigment bodies in fossilised dinosaur feathers from rocks in China and worked out that the dinosaurs - which lived in forested lands around 125 million years ago - sported alternating stripes of white and reddish brown or ginger. "The colours themselves are interesting, but so are the stripes," says Dr Orr. "We can start thinking about whether the patterning may have helped as camouflage, or was it for show."

Key research interests:

History of life on Earth
Evolution
Fossil preservation
Quality of the fossil record
Ancient ecosystems

Fieldwork in China studying 125 million year old lake sediments

Meanwhile, in Spain, Dr Orr's team discovered preserved red and yellow bone marrow from frogs that lived more than 10 million years ago, which was a landmark finding and one that has prompted others to go looking for marrow and muscle in the fossil record, he says.

Rocks in Morocco turned up another trove of soft-bodied fossils for the researchers - this time showing a previously undocumented richness in marine life in the Lower Ordovician period around 475 million years ago. "This is important because it gives us a much richer picture of biodiversity in the sea at a time when communities of organisms were becoming more complex," says Dr Orr.

He is now continuing to fill in the picture of evolution on Earth with evidence from soft-bodied animals - particularly marine creatures - and the traces that their activities and behaviours have left behind in rocks. "If you know where and how to look, these fossils can help us to understand a bigger picture," he says.

Professor Padraig Dunne

Associate Professor, UCD School of Physics

The 'next big tin' for faster, cheaper electronics

Tin has a reputation as a cheap and functional metal - useful for plating and for making durable bowls and pots. But research at UCD is showing that tin's talents could shine even more brightly in the drive to build faster and cheaper electronics.

The key is in understanding how tin can be used as a laser-produced plasma source for etching tiny patterns on semiconductors, explains Professor Padraig Dunne, an Associate Professor and Head of School at UCD School of Physics.

"These features are 'written' in the silicon with light, and if you can produce smaller features in the silicon then you can make transistors faster and cheaper," he says. "So the goal in industry is to be able to use a light source around 13.5 nanometres, resulting in features below 15 nm in size. By comparison, green light has a wavelength of 550 nm."

Previous work at UCD, with physicists Dr Emma Sokell and Professor Gerry O'Sullivan helped to single tin out as a useful source for generating lasers of this wavelength, explains Professor Dunne, and part of the science behind their approach has been to better understand how tin behaves at an atomic level.

Each tin atom includes a cloud of electrons, and if you take some electrons out of the cloud the remaining electrons reconfigure, which in turn can affect the tin ion's behaviour in a light source. "If you can understand how the electrons adjust, then you understand how these ions emit light and you can figure out where they are brightest and where they are not bright," says Professor Dunne. "Then you can start tailoring the ions to be light sources."

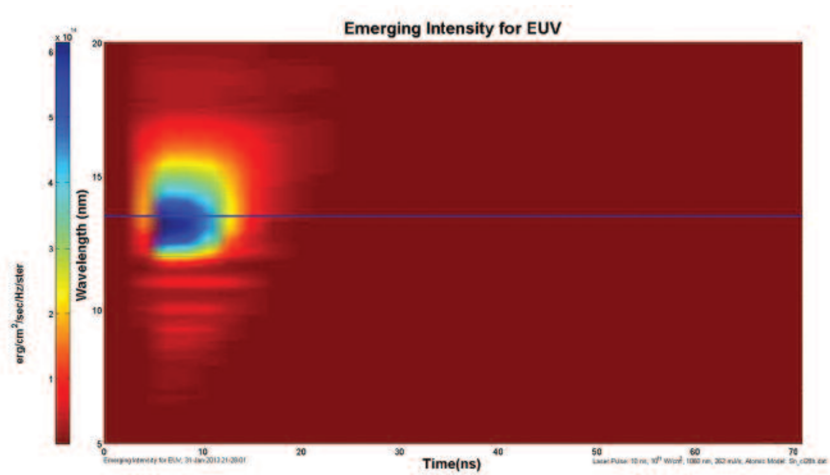
Key research interests:

Spectroscopy

Experimental Physics

Atoms & Ions

Laser-produced Plasmas



But while tin can produce 13.5 nm light, at the moment it's not terribly efficient. So the UCD physicists are tweaking the approach to try and get more of the light they need out for the power they put in - and improving the laser-to-plasma output by even a few percentage points could offer enormous gains, notes Professor Dunne.

"It is difficult to get enough light of the right wavelength out of the plasma, so we are trying to figure out what can we do to improve the conversion efficiency," he says.

"We fire lasers at materials and we look at the spectra coming off them when we change the colour of the laser, the power density and the angle. And we have recently started making two plasmas collide into each other and hitting that with a laser, because the density of that colliding plasma is better for absorbing laser light than a solid target would be."

UCD campus company NewLambda Technologies is now working on commercialising the laser-plasma source technology for use both in the semiconductor industry and, in the nearer term, for new and cheaper light sources in microscopy, explains Professor Dunne, who is the start-up's Director for Business Development.

Dr Grace Morgan

Senior Lecturer, UCD School of Chemistry & Chemical Biology

Spinning new solutions with magnetism

The word 'magnet' may well conjure up an image of a horseshoe-shaped bar picking up paper clips, but co-ordination chemist Dr Grace Morgan has her eye on something considerably smaller. She is looking to harness the atoms of metallic elements, where the spin of the electrons determines their magnetic properties. And by cleverly engineering transition metals, she is opening up new possibilities - including how to store information more effectively on electronic devices.

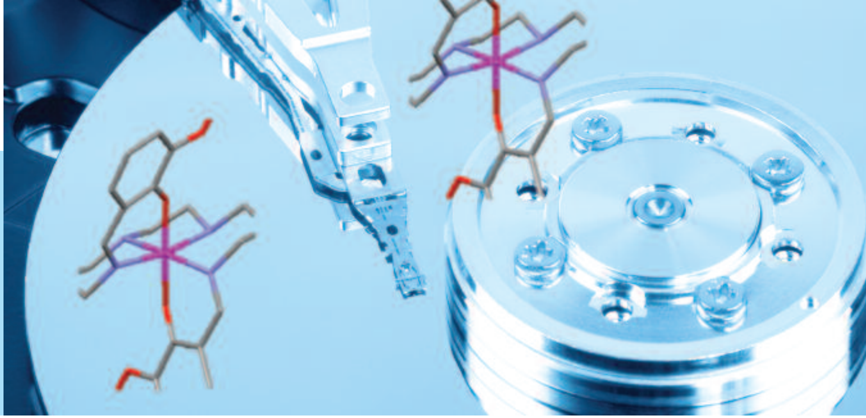
"At its heart any electronic device is an assembly of chemicals, that, through state changes, processes and stores information," explains Dr Morgan, who is a Senior Lecturer at UCD School of Chemistry and Chemical Biology. "There is always a demand for increased processing speeds and for higher storage capacity, and industry is now looking to get down to the molecular level to do that."

Dr Morgan's approach uses transition metal molecules that can exist in two states, both of which are stable under the same conditions: by switching the spin of their electrons, you could effectively process or store new patterns of information in the chemical arrays, she explains.

"We work with a set of transition metal complexes where you can store information inside the molecule - by changing the temperature we can switch between a high-spin and low-spin arrangement and this lets you manage the information in your device."

Key research interests:

Spintronics
Magnetic switching
Data storage
Molecular memory
Quantum tunneling
Spin logic


Data storage will soon be at the level of a single molecule

At the moment Dr Morgan uses the metal manganese for the spin switching and published a paper in 2012 about its spin transition in the prestigious journal 'Angewandte Chemie'. Her lab is now designing a chemical framework around the metal. "It is like a little tap you can turn on spin," she says. "And if you can decorate the ligand around the metal, you can make it into a nano-object which in turn makes it easier to engineer."

Dr Morgan is also looking to engineer 'soft media' switches using ionic liquids, where magnets could be used to 'write' the information into the chemistry. "We can put the switches on a nano-fluidic surface and manipulate them with magnetic fields," she explains. "Different droplets will have different spin states, so they will respond differently. But this is quite difficult to achieve."

As these transition metals flip between spin states, they absorb heat, but they don't become hot - a phenomenon known as phase transition - and Dr Morgan is working with industry to explore how they could help to control heat in devices.

"The challenges now are to engineer these materials so that they operate over many years without degradation and that they will work across a range of temperatures, whether they are in Alaska or Australia."

Her lab is also exploring how to engineer transition metals so they can 'pull' carbon from the atmosphere, and thus provide material for making fine chemicals. "It's a free source of carbon and it's the final sink for fossil fuels that are burnt: if you recover that and make fine chemicals that would be very useful for indigenous industry."

Dr Paul McCabe

Senior Lecturer, UCD School of Biology & Environmental Science

Exploring the benefits of death in plants

It's a macabre thought, but death is a part of life. At a cellular level, individual cells need to die off in a controlled way to sculpt and renew tissues and to stop the spread of disease.

While plenty of research goes into the death processes of animal cells, Dr Paul McCabe is looking to understand how 'programmed cell death' is controlled in plants, with a view to better management of infection or stress.

"It looks like every single plant cell has a special mechanism that it can activate to kill itself," says Dr McCabe, who is a Senior Lecturer at UCD School of Biology and Environmental Science. "And plants use it as they develop and also to protect themselves: if a plant cell recognises a disease-causing pathogen it switches on the death programme. It basically sacrifices itself as well as killing the pathogen to protect the rest of the plant."

Dr McCabe is interested in the genetic mechanisms that underpin programmed cell death in plants, and at how plants use it to react to potentially stressful situations like infection or a harsh environment.

He works with Professor Fiona Doohan on what happens to plants when they are infected with the fungus Fusarium graminearum, a costly pathogen of wheat, barley, corn and rice.

"The fungus infects these food crops with molecules called mycotoxins," explains Dr McCabe. "But we don't know much about what they do."

His lab found that when plant cells are exposed to the fungal toxin, a curiously complex relationship emerges, he explains. "At low levels the mycotoxin seems to stop the cells from switching on programmed cell death but if you really ramp up the mycotoxin it does start to kill the cells. So it seems to manipulate and play with these cell death programmes."

Key research interests:

Plants

Food

Wheat

Mitochondria

Death

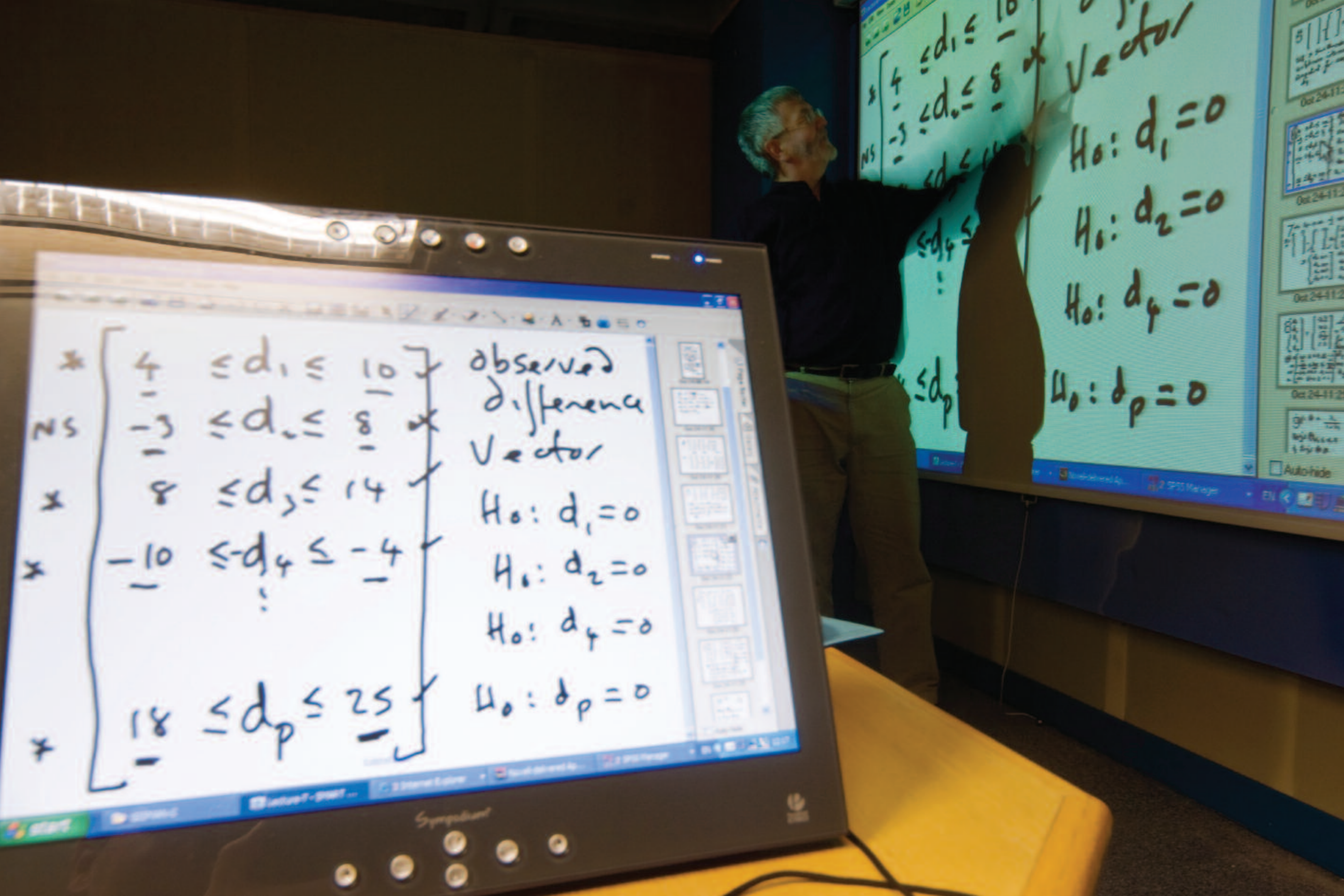
Healthy and diseased wheat head

In parallel, Dr McCabe's lab is exploring the roles of cell death in a mutually beneficial interaction between a nitrogen-providing alga called Nostoc and plant cells. And he is looking at how cell death levels could also act as a proxy for stress tolerance - research in his lab found that wheat seedlings that can withstand high salt conditions have high levels of programmed cell death, which seems to be linked with hardiness in the harsh soil.

"So perhaps if you have lots of bred lines you don't know which of these are salt tolerant and which are salt sensitive, we could do a very quick screen of seedlings for programmed cell death, which would be faster than a whole plant analysis," he says.

Dr McCabe's research, which is funded through Science Foundation Ireland, the Irish Research Council and the Department of Agriculture, Food and the Marine, is also looking under the hood to understand how the mitochondrion may be the cellular ringmaster in controlling the life and death decisions of a plant cell.

"I think it's fundamentally important that we understand programmed cell death in plants," he says. "If you know what is happening and how the process is targeted by threats like pathogens, you could potentially strengthen plants against attack."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UCD Science Showcase 2

Cognition & Education

Dr Fred Cummins

Senior Lecturer, UCD School of Computer Science & Informatics

When two (or more) voices join as one

What happens when we speak in unison with others? What's different about 'joint speech' compared to the more common 'one talks and one listens' dynamic? And why would we want to speak in chorus anyway?

Those are some of the questions exercising cognitive scientist Dr Fred Cummins, a Senior Lecturer at UCD School of Computer Science and Informatics.

In recent years Dr Cummins has developed a particular interest in joint speech, where two or more people voluntarily say the same thing at the same time. Distinct from conversation or oration, we tend to engage in joint speech where there is a common purpose or intention, he explains. "We tend to speak in unison in situations of great social importance - like religious rites, swearing collective oaths or if we are protesting in a demonstration, where we are saying 'I am along with these people'. It provides a strong expression of group purpose, or belief. Joint speech challenges us to understand our selves at a level beyond the individual."

Dr Cummins takes several approaches to the study of joint speech, including observing chanting in houses of worship and on the street and also analysing brain scans to see how brain activity is different when we speak singly or together. In work together with Professor Sophie Scott and Kyle Jasmin at University College London, it has been found that the brain shows distinct patterns of activity when we commune through speech.

Key research interests:

Joint speech	Intersubjectivity
Chant	Speech
Prayer	Rhythm
Coordination	

"We find the activity in the brain is very different when people are speaking together in synchrony with someone else - it's different even from speaking along with a tape recorder," he says.

Dr Cummins is currently developing computer-based technologies to harness the power of joint speech, though he points out that joint speech itself has been used as a technology to preserve information for thousands of years. "It has provided a means of keeping certain texts alive, such as the Vedic scripts, which have a 3,000 year old history, but for most of that, the texts were not written down - they were all preserved syllable by syllable through having a particular technique of chanting together," he explains.

"Now I am looking to develop new technologies for joint speech. Imagine if you had a digital petition online and instead of signing it you spoke it, so the person receiving it listens to the voices of thousands of people. Or imagine after Fukushima or 9/11 a community comes together and creates a collective recording as a tribute, and this passes around social media. It would bear a significance that goes beyond passing a message - everyone is saying the same thing."

Dr Kathy O'Boyle

Senior Lecturer, UCD School of Biomolecular & Biomedical Science

When students learn from students

If there's a problem to be tackled, many heads are often better than one. And, thanks to the Peer-Assisted Learning (PAL) programme in UCD, first-year chemistry students can now get their heads together in constructive, guided study sessions to tackle the more challenging parts of the course.

"Peer-assisted learning is a form of learner support for all students," explains Dr Kathy O'Boyle who, as Vice Principal for Teaching and Learning at UCD College of Science, was very involved in the development of this programme.

"It gives students an opportunity to learn from each other in sessions facilitated by PAL leaders who are usually students from the year above, in an environment that is completely safe and where the students can ask questions about the material they are learning."

The approach, which was originally developed in the United States in the 1970s, is now being used in first-year chemistry modules in UCD where two peer leaders drawn from higher years work with a group of younger students. PAL doesn't provide additional material in the way that a tutorial would, instead it encourages the students to identify areas of the course that they find challenging and to tackle it with their shared knowledge, explains Dr O'Boyle.

"The PAL leaders are not meant to provide direct answers," she says. "Through probing questioning and through breaking topics down into smaller elements, they help the student group get to grips with the basic concepts. It can be a challenge - the students are used to asking a question and getting a quick answer and they can initially find it frustrating having to work it out themselves."

But by collaborating to solve the problem - or at least figure out what they need to do to address it - the students get to practice speaking the language of the subject, and research from Europe and the US suggests that this deepens their learning and enhances their grades, according to Dr O'Boyle.

The PAL leaders benefit too. They undergo a two-day training course in facilitation techniques and group management strategies and they learn how to ask questions so that the students in the PAL group will think their way to answers. And so far there has been no shortage of volunteers. "At the moment we are getting more students trained up as leaders than we actually need to run alongside the programme," says Dr O'Boyle.

It's early days yet but the results are now feeding into research about the impact of the approach on student engagement and grades. "We would like to roll PAL out further so that all first years experience PAL in at least one module, because it benefits both the first years and also the students in the years above, who develop leadership skills."

Dr O'Boyle and Ms Aoife FitzGerald (Student Advisor) trained as PAL supervisors with the UK National Centre for PASS, University of Manchester.

Key research interests:

Monoamine neurotransmitters
Thyrotropin-releasing hormone
Neurotoxicity
G-protein-coupled receptors
Peer assisted learning
Enquiry-based learning

Dr Mike Casey

Senior Lecturer, UCD School of Chemistry & Chemical Biology

Power to the students: turning the chemistry lecture around

Sometimes taking a standard format and flipping it around can lead to new and perhaps better ways of doing things. So when Dr Mike Casey started to think about the limitations of the standard chemistry lecture, he turned it on its head.

"Around five years ago I became much more aware of the limitations of the traditional pedagogy of giving a lecture," says Dr Casey, who is a Senior Lecturer at UCD School of Chemistry and Chemical Biology. "The lecture definitely has its place, there is no question, and it can be done very well, but at the same time it doesn't tap into all the possibilities, so I began reading the literature and trying to make the lectures a bit more engaging."

For one thing, he got the first-year undergraduate students to engage more actively with the material: he encouraged them to have discussions and solve problems during class instead of simply receiving the information. "I think because they are engaging with the material and doing problems, it is better for their learning," says Dr Casey.

More recently he has been expanding that interactivity by piloting a 'flipped classroom' model, where the students prime themselves with the lecture material before the class.

"You give the students the lecture notes or the reading from the textbook in advance and ask them to read it and think about it and maybe do a little quiz ahead of the class," he explains. "Then almost all the class time is given over to problems and discussions."

In practice this helps the students to understand fundamental concepts, such as how buffers work, which in turn can help prepare them for the practical elements of the course too.

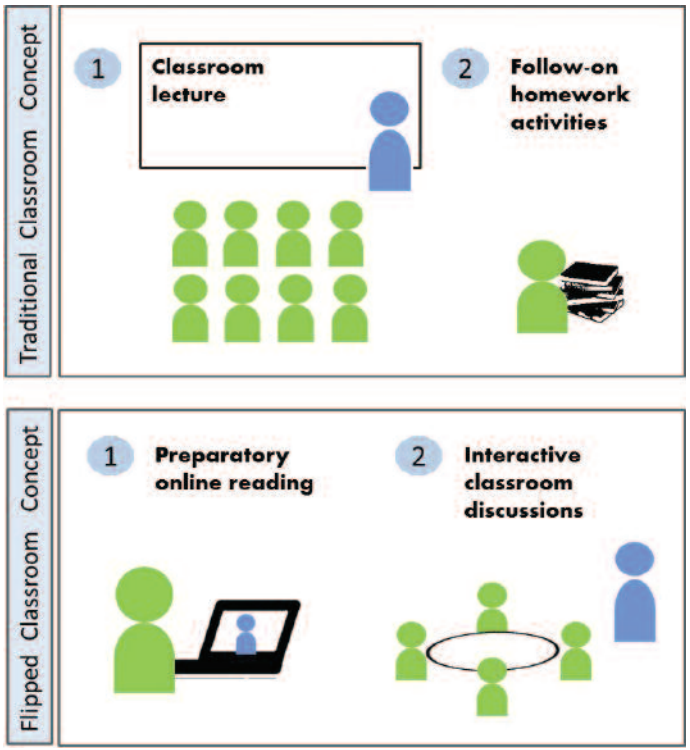
Key research interests:

Chemical synthesis

Organic chemistry

Educational research

Online learning



He has also been harnessing the power of software to get students thinking about the nuts and bolts of chemistry using an online tutoring programme. "The students have to draw chemical structures and reaction mechanisms," he explains. "The software is able to analyse their answers in a chemically intelligent way and give them feedback."

Dr Casey credits the UCD Centre for Teaching and Learning with catalysing his interest in this area, and he is now attending conferences and researching more ways to make learning interactive. "That is making me aware of the possibilities but also of the limitations of what is currently available," he says. "There are opportunities to go much further here."

And as Dr Casey introduces the more interactive and 'flipped' modes to larger numbers of students, he is struck by how well the students work together.

"The thing that has the biggest impact on me is the recognition of the importance of that peer interaction," he says. "I am convinced of the value of getting students into the habit of coming together into groups and collaborating."

Dr Patricia Maguire

Senior Lecturer, UCD School of Biomolecular & Biomedical Science

Who wants to be a biomedical scientist?

If you were on the quiz show 'Who Wants to be a Millionaire' and you had to choose what subject to study at college, would you know whether to click a, b, c or d? When you have to make a choice like that, it helps to have a good foundation in the options. So for first-year (Stage 1) students, an introductory module on biomedical science offers just that... with a bit of game-show interaction thrown in.

Now in its third year, the second-semester module offers students a smorgasbord of the basics in biochemistry, genetics, microbiology, neuroscience and pharmacology, explains co-ordinator Dr Patricia Maguire.

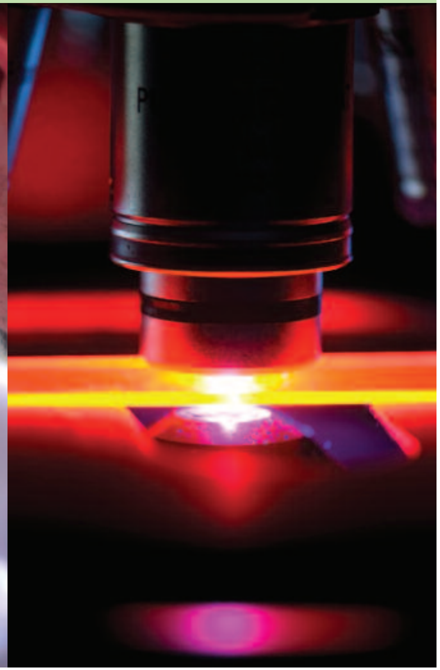
"Among the most popular degree courses in UCD Science are neuroscience and pharmacology, but this module gives the first years starting out a flavour across the biomedical subjects," she says. "The key here is they can experience all those subjects before they make their choice, and no matter what they go on to study they have this foundation across the subjects."

Dr Maguire uses some interesting teaching methods to engage with the students in her lectures, including a game-show-style clicker. Each pair of students has a clicker device and, like on 'Who Wants to be a Millionaire', they click their answers to multiple choice questions, explains Dr Maguire.

"In the first lecture I use the questions to find out how many students have studied biology at school and what their interests are - it's a real icebreaker," she says. "Then as we do the course the students answer questions on what we have just covered - it is noisy but fun, and it gets them talking to each other about science."

Key research interests:

Platelets
Secretion
Signalling
Exosomes
Inflammation
Biochemistry

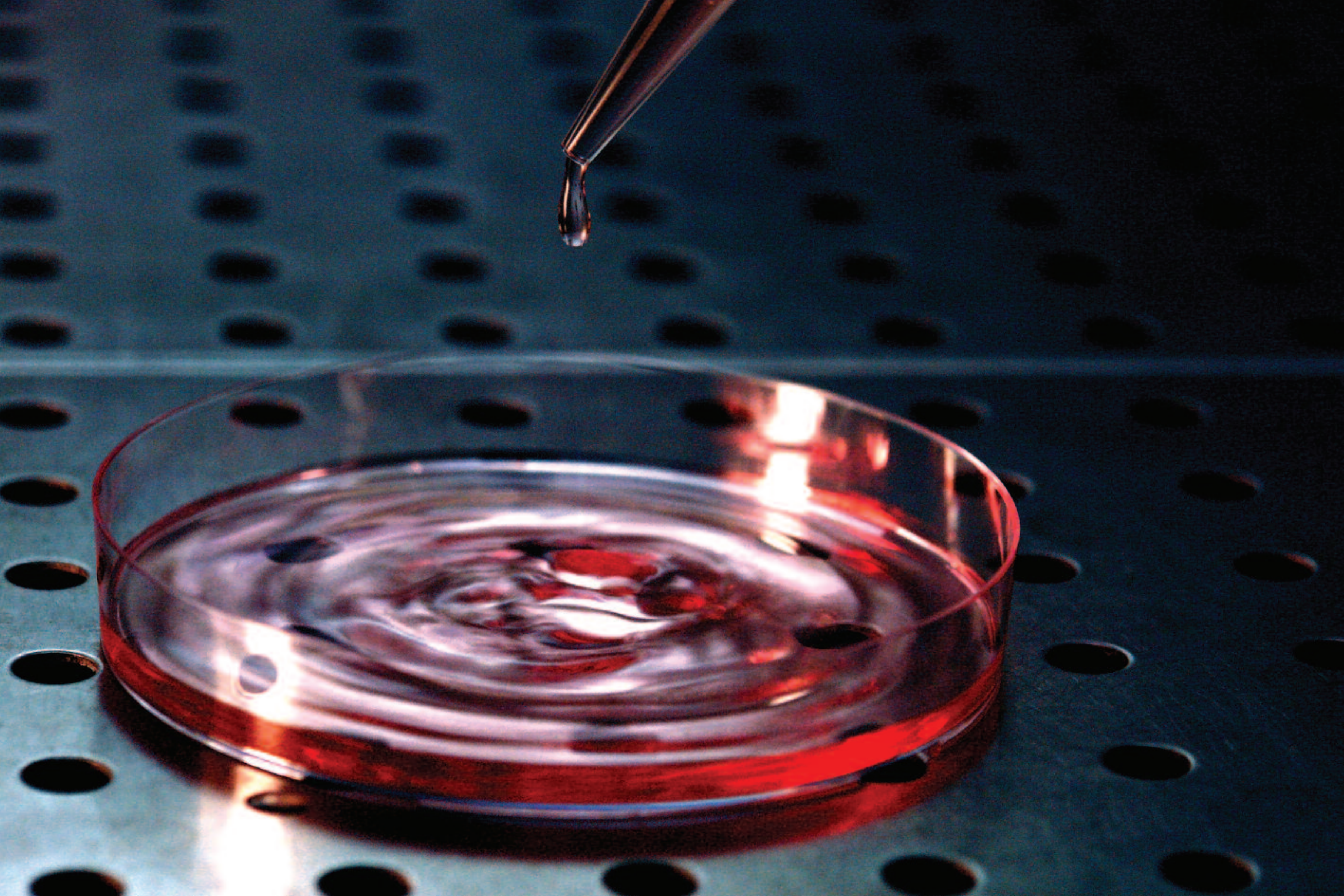


"My colleagues also use videos as student learning aids and there's even a bespoke book that we have specially prepared for this course."

"These methods make the classes more interactive - the students will stop me and ask about something I've just said, and I usually have a queue at the end of the lectures to ask questions," says Dr Maguire. "And we keep the topics relevant: in one lecture I talk about the toxicity of paracetamol. It's straightforward pharmacology and they get it."

Dr Maguire, who is a Senior Lecturer at the School of Biomolecular and Biomedical Science, also tells the students about her research into platelets and the cardiovascular system. "I think that is really beneficial that even at this early stage the students get to hear about the research that is being done at UCD," she says.

The overwhelming response from students - who provide feedback anonymously online - is one of enthusiasm, and the game-show-style is a particular winner, according to Dr Maguire. "They love it; it turns a lecture with 300 people into something much less formal and more interactive."



UCD Science Showcase 2

Health

Dr Keith Murphy

Senior Lecturer, UCD School of Biomolecular & Biomedical Science

A grassroots approach to treating brain disease

The brain and nervous system have crucial roles in the body, so their health is a big issue. And conditions that involve their degeneration (including Alzheimer's disease and multiple sclerosis), or other presentations such as schizophrenia and depression, pose challenges for treatment.

Dr Keith Murphy and his team are taking a grassroots approach to identifying new possible treatments, by getting to grips with the biology of how the brain works, and how the biology changes in disease or dysfunction.

"This is a field where there is a really big need at the moment because we haven't had improved drugs to treat a lot of brain and nervous disease for quite a long time now," says Dr Murphy, who directs the Neurotherapeutics Research Group at UCD School of Biomolecular and Biomedical Science.

The research group takes a back-to-basics approach to develop new treatments for major devastating brain and nervous system diseases, he explains. The idea is to mine into the biology of function and dysfunction to find key molecules that clinicians could measure to diagnose disease, or that could be targeted in treatment.

"In general, the field is at the point of identifying new targets and new biomarkers in order to drive a wave of new treatments over the next decade or two," says Dr Murphy.

Rather than focusing on a particular disease, the Neurotherapeutics Research Group homes in on important brain functions that are often compromised in diseases - in particular memory and learning, he explains: "Because memory goes wrong in lots of diseases, the idea is that if you understand the drivers of memory you can develop drugs that help in those diseases."

Key research interests:

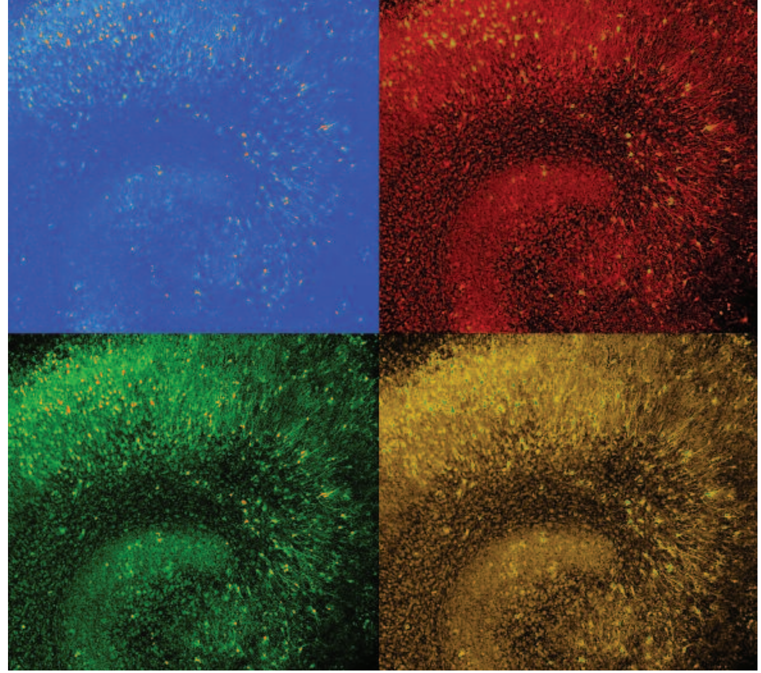
Memory

Flexible nerve connections

Brain disease

New treatments

New diagnostics



So far, the group has identified hundreds of proteins where the expression changes in the brain during learning, and they have shown that many of those proteins are also altered in models of disease.

They are now focusing in on around 20 of those proteins to develop suites of potential 'biomarkers' that could help to improve the diagnosis of brain disease, and help to monitor how a patient is faring on treatment.

The UCD researchers are also developing a new potential treatment for multiple sclerosis, which looks to boost repair of the insulating sheath around nerves that gets damaged in the condition.

Dr Murphy, who is a Senior Lecturer of Pharmacology, teaches pharmacology to undergraduate students at UCD, and he considers it an important basic component in biomedicine.

"I think that is important for the students to learn how drugs work and how they are developed, even if they don't go on to specialise in pharmacology," he says. "As a biomedical research scientist you need a good appreciation across several disciplines."

Dr Kay Nolan

Senior Lecturer, UCD School of Biology & Environmental Science

Can dog genetics provide new leads for human disease?

The dog might be man's best friend, but could canine genes also be a friend to genetic research? Thoroughbreds can offer a relatively clean canvas to go looking for genes that are linked with disease, explains Dr Kay Nolan, a Senior Lecturer at UCD School of Biology and Environmental Science.

"Each breed is a closed genetic population, so there is less genetic diversity within the breed than in the outbred dog population or in the human population," she says. "And an individual breed may have either its own simple genetic disease due to a mutation in a single gene, or it may be susceptible to a more complex disease that has to do with multiple genes and perhaps environmental factors."

Dr Nolan is working with colleagues from UCD School of Veterinary Medicine to tease out the genetics of conditions that crop up in Japanese Spitz and Greyhounds.

The work on the Japanese Spitz breed focuses on a muscular dystrophy that presents as muscle weakness and abnormal gait that worsens over time, and Dr Nolan and Sabela Atencia Fernandez discovered the underlying mutation.

"We developed a straightforward test based on DNA from saliva swabs that could identify carriers or individuals with the mutation for the condition," says Dr Nolan. "We have made that test available to the public, and this could facilitate breeders in breeding the mutation out of the population."

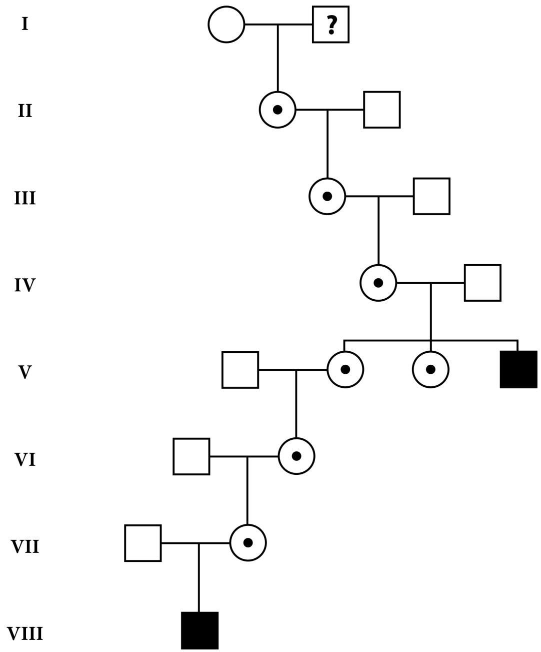
At a more fundamental level though, further research into the findings could also feed into our understanding of human muscular dystrophy, she adds.

"The fact that some dogs have mild symptoms and others have very severe symptoms is interesting because that is also true in human muscular dystrophy," she says. "If you knew the basis for that it could potentially open up new avenues for therapy."

Key research interests:

Epigenetics
Inherited diseases
Animal development
Genomic imprinting
Canine genetics

DNA saliva swab administered by Sabela Atencia Fernandez from UCD Veterinary Medicine



Animal genetics family tree

Dr Nolan is also working on the genetics of a type of brain inflammation that can afflict Greyhounds in particular. "The affected dogs become blind and they have weird circling behaviour, and previous work at UCD has indicated there's a genetic component," she says. "This is interesting because brain inflammation seems to go out of kilter in many neurological disorders in humans, so it's a hot topic, but it's hard to get a handle on the genes involved in humans because of the genetic diversity in the population."

Dr Nolan and colleagues have now identified a region of interest in the Greyhound genome that seems to be associated with the brain inflammation, and the plan is to explore it in detail to tease out the genes that are present: "The idea is that because the breed has a more limited genetic pool than humans, it might be easier to find the underlying genetic predispositions in the dogs."

Professor Pat Guiry

Professor of Synthetic Organic Chemistry, UCD School of Chemistry & Chemical Biology

Building on nature´s chemistry

Over billions of years, plenty of neat solutions have evolved in nature. And with the right know-how, we can harness some of those natural 'fixes'. For Professor Pat Guiry, Professor of Synthetic Organic Chemistry, nature inspires at a chemical level.

"I have an interest in medicinal chemistry, in the development of drugs," he says. "Nature has already provided humankind with so many different molecular architectures that have already shown a diverse array of biological properties.

As a synthetic organic chemist I'm interested in new ways to make these compounds in the lab in a manner that also allows for making closely related compounds that are perhaps even more active than the originals in nature."

So where does one go looking for such natural inspiration? Marine algae have recently proven to be a rich hunting ground for chemists. One project, which saw Professor Guiry's group working with colleagues at Dublin City University, took samples of algae growing off the west coast of Ireland. The researchers split the algae into crude chemical fractions and tested the fractions for biological activity to 'sniff out' an interesting compound, explains Professor Guiry. "We kept following the biological activity until we isolated a pure compound, then we are able to use spectroscopy to find out what its structure is," he says. The isolated compound could have applications in modulating the immune system, and the UCD chemists are now making versions of the molecule in the lab.

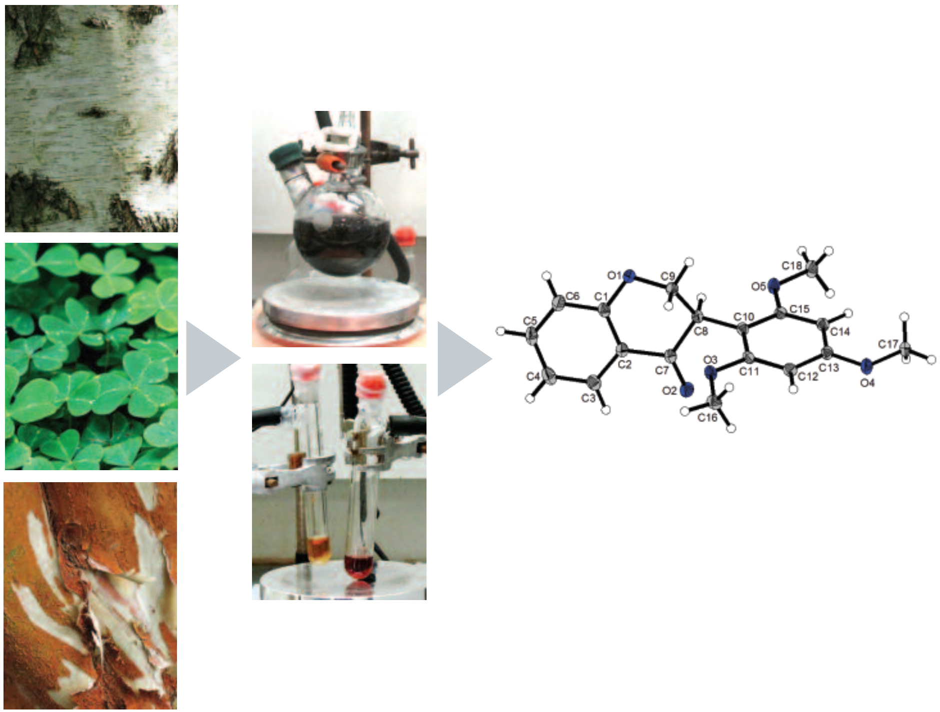
That wasn't the only alga to come up trumps - during another recent project in Professor Guiry's lab, one of his students noticed an interesting by-product when making a toxin that is naturally produced by a blue-green alga. That avenue led the scientists to make a new set of molecules, two of which have shown 'quite exciting activity' against microbes, he explains.

Key research interests:

Natural Products Chemistry

Asymmetric Synthesis

Developing New Catalysts



Of course, such compounds need the right conditions to form, and the devil is in the detail: the slightest change in the three-dimensional shape of a chemical can make all the difference. So Professor Guiry's lab specialises in using environmentally friendly chemical agents called catalysts to precisely build complex organic compounds. "There's no doubt from an economic and environmental point of view the catalytic approach to making these molecules will be of enormous benefit," he says.

Using the approach, researchers in Professor Guiry's group recently cracked a tough nut in chemical synthesis: how to make isoflavanones, a class of plant compounds that have potential anti-cancer and anti-inflammatory activities. "They are notoriously hard to make, but with a lot of hard work and dedication by the students we developed a new method for making them through a process of asymmetric catalysis," he explains.

Professor Guiry is also applying his expertise in catalysis in the Science Foundation Ireland-funded Synthesis & Solid State Pharmaceutical Centre. Led by the University of Limerick, the Centre is bringing academic institutions and companies together to work on therapeutic drug synthesis.

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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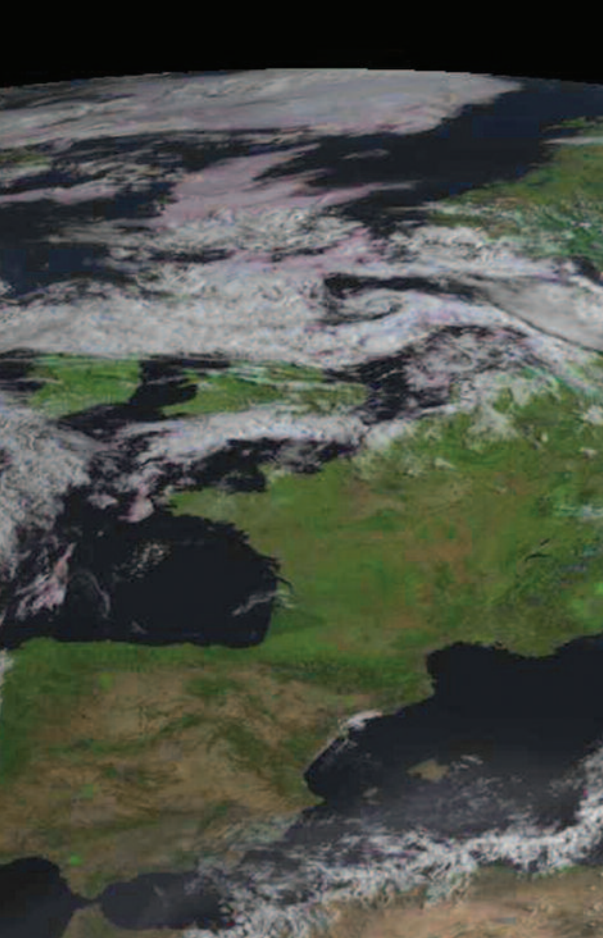

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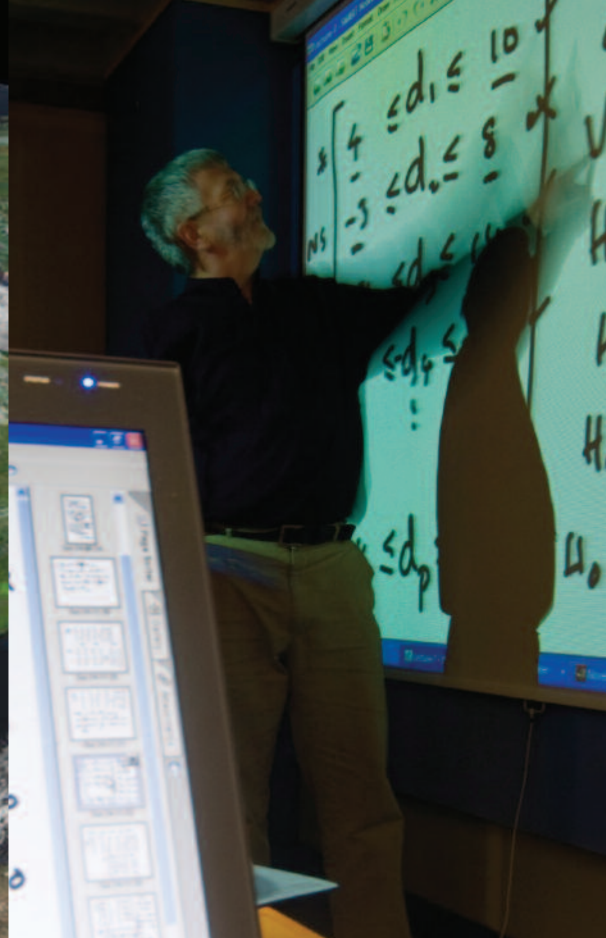

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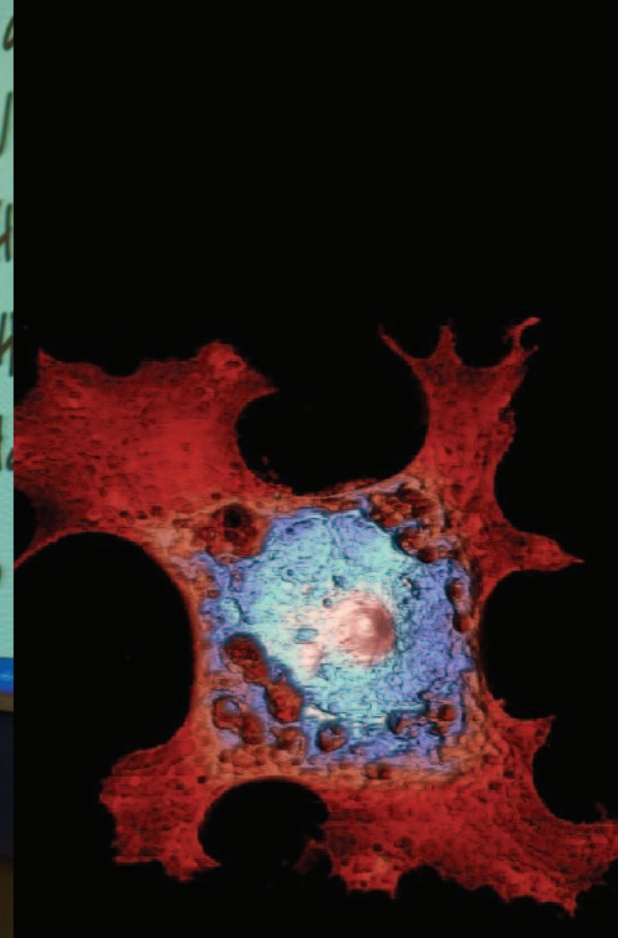

Health

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