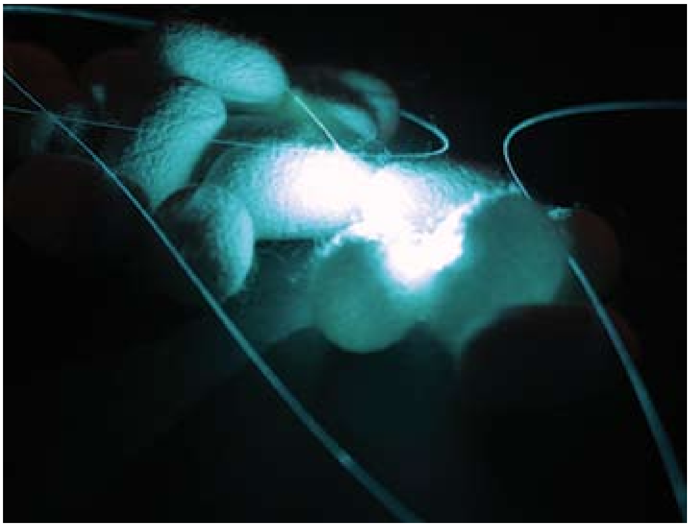
SCHOOL OF PHYSICS

FACULTY OF SCIENCE

THE UNIVERSITY OF SYDNEY

Alumni News

WINTER 2010



BIOPHOTONICS & THE SILKWORM REVOLUTION

While a postdoc at Tufts University in Boston, Dr Peter Domachuk and his colleagues had the revelation of using protein to make an optical chip in strip form to monitor health. Two years on and the idea has become closer to the reality of producing a networked interface to the human body that can potentially provide an unparalleled standard of patient care by ensuring correct, efficient diagnosis and treatment without drawing blood or using lab tests.

The idea was developed when a colleague's four-year-old daughter swallowed unknown quantities of different medicines from her grandparents' medicine chest. Against all odds the little girl survived as she had refused to allow any doctor with a needle near her to obtain a blood sample.

"Even if a doctor had been successful in getting a blood sample it still would have taken hours for the results to come through," says Dr Domachuk, a Research Associate within the Institute of Photonic and Optical Science (IPOS) based at the School of Physics. "By using an optical chip in a strip form on her wrist an accurate toxicology report would've been generated almost instantly and in a minimally invasive fashion saving much stress, pain and trauma on the child, her parents and the attending medical staff."

The strips are flexible optical chips combining biochemistry, light, electronics and medicine that plug into, or under, the skin, instantaneously analysing and communicating the torrent of medical

CONTINUES OVERLEAF

TUNNEL VISION

BENEATH HILL 60

An Australian movie, *Beneath Hill 60*, dramatises a WW1 campaign that featured the ingenious work of Professor James Pollock, former Head, School of Physics. David Varvel, former General Manager, Science Foundation for Physics, has the full story.

James Arthur Pollock FRS, had been Head of the School of Physics for 16 years when he saw his opportunity to serve his adopted country. In November 1915, the Federal Defence Department decided to form a military mining corps of two battalions. Pollock seized the opportunity, and within a month had developed a specialised geo-telephone to detect underground sounds. When he demonstrated his invention to the Defence Department they were so impressed that he was immediately appointed to join the Australian Mining Corps with the rank of Captain on 1 January 1916.

The Corps arrived at Alexandria in April 1916 and over the next year Pollock took charge of the Mining School at Proven near Poperinghe. Here he established a military physics laboratory and his field of research was the transmission of sound waves through the earth and instructing officers and NCOs' of all of the Allied tunnelling companies in the best methods of using the newly developed French Geophone to listen for enemy tunnellers. Pollock was not just a back room physicist. At times the geophones had to be tested and he often went with the No. 1 Australian Tunnelling Company into the tunnels under Hill 60 to ensure the instruments were functioning under front line conditions.

In all, there were over allied 8,000 tunnellers at work under the ridges of Messines and Wytschaete, which were held by German troops. The tunnels started often a kilometre behind the allied lines and at times were over 90 feet below the surface of the ridges.

Once the tunnels were complete, twenty-one mines were laid under the ridges below the German lines. These ranged from a few to over 40 tons of Ammonal explosive (ammonium-nitrate, trinitrotoluene and aluminium powder).

At 3.10am on the morning of 7 July 1917 the mines were detonated. Nineteen of the twenty-one mines exploded in an explosion so powerful it was heard in London and Dublin. It was estimated that over 10,000 German soldiers

CONTINUES OVERLEAF

WHERE ARE YOU NOW?

Matthew Georgiades an ISS2009 scholar and winner of the DIISR sponsored Len Basser Award for Scientific Leadership is now an undergraduate at The University of Sydney told *Alumni News* how he was enjoying his time as a uni student.

I'm enrolled in a Bachelor of Science (Advanced) – taking Physics, Chemistry, Human Biology, Differential Calculus and Linear Algebra. I'm enjoying myself very much! I'm finding the content of lectures very interesting, especially now when things start to step up a gear as revision of HSC material turns into learning and discovering new things I never knew.

I love the opportunity to dapple in a wide variety of science and am excited by what I might encounter in the coming weeks, months and especially years of my studies.

I have been fortunate enough to obtain a Faculty of Science Entry and Alumni Scholarship which I am very grateful for, considering the associated costs with studying and having the flexibility now to not have to work as many hours per week in my job.

I'm also involved with the Talented Students Program (TSP). It's exciting to be undertaking a research project for the TSP Showcase on the topic of tissue engineering under the supervision of Professor Tony Weiss.

It's also been great bumping into fellow ISS alumni around the campus and there are even a few who are enrolled in many of my subjects. This has been great for fostering friendships from the Professor Harry Messel International Science School (ISS) that otherwise would be very difficult as we all come from different places, but University gives us the opportunity to see each other and catch up quite often, just like the ISS days.

I continue to think about the ISS, the amazing things I got out of it and the opportunities it gave me. I'm so grateful for the time I spent at the ISS, not only for the amazing things I had the opportunity to learn but for the questions it encouraged me to ask, and the answers to the questions I want to use during my time at university.

I look forward to the possibility of returning to the ISS2011 as a Staffie and having the opportunity to go through it all over again!!

Matthew Wardrop, ISS scholar, ISS Staffie x 2 and current Hons Physics student gave *Alumni News* a brief catch up when we stopped him in the corridor recently and demanded to know what he was up to…

I attended my first ISS, *Waves of the Future*, in 2005 and for perhaps the first time, caught glimpses of the very forefront of contemporary scientific endeavour. This reaffirmed my already established desire to undertake a BSc at the University of Sydney.

Now completing my final year (Physics Honours in Quantum Information Systems) I remain as enchanted as ever with science. I'm thankful for the amazing opportunities I've had to learn, understand and tinker with science. Whether I'll continue PhD studies or find myself in another field, my scientific fascination with the mechanisms of our world will always persist.

BIO-PHOTONICS & THE SILKWORM REVOLUTION CONTINUED FROM PAGE 1

information that humans produce. However finding an appropriate material that had a low-immune response; was robust and able to be used as a platform for biochemistry and optics initially eluded Dr Domachuk.

"My colleagues were researching the refinement of silk protein from the cocoon of the Bombyx morii silkworm for use in artificial ligaments. With a small modification to the refinement process I was able to create strong, clear films of silk protein with favourable optical properties that meet the criteria for making optical chips for health and biological sensing."

Dr Peter Domachuk, Research Associate within the Institute of Photonic and Optical Sciences (IPOS) at School of Physics

Dr Domachuk's research pioneered manipulation of light on the protein chip and demonstrated silk's versatility in an optic, patterned to manipulate light based in silk film that contained blood—the optic being used to measure the reactivity of the blood. Not only could the film support human biochemistry on an optic, he and his colleagues then discovered that the films have no immune response when implanted in the body.

"That was pretty exciting especially as these protein films can be stamped with structures 1/1000th of a width of a human hair. The combination of human biochemistry and optical devices on a chip made from natural protein is unprecedented," Dr Domachuk says.

By using this protein to make optical chips Dr Domachuk says diagnostic medicine will be transformed, ensuring quicker, more effective and accurate measurements and monitoring, particularly in triage treatment, remote area medicine and military hospitals based in war zones. "This optical chip is not only going to help save lives but will underpin new research into further revolutionary medical technology. This is just the beginning."

FOR MORE INFORMATION ON IPOS VISIT:
WWW.USYD.EDU.AU/IPOS/

TUNNEL VISION CONTINUED FROM PAGE 1

died on that terrible morning and the allies were able to break through the German lines and achieve all of their objectives by nightfall of the same day. This operation was so successful that German military mining was almost totally eliminated and the Mining School at Proven was closed.

After this action he was transferred at the special request of the War Office to Brookham near Farnborough to work on aircraft orientation and navigation at altitudes of over 10,000 feet and without reference to compass or the ground. This work was the beginning of aircraft instrument navigation and continued till the experiments were stopped by the Armistice on November 11, 1918.

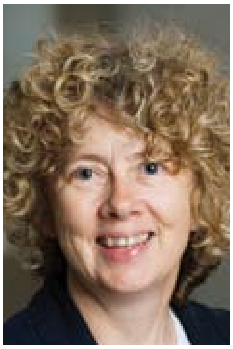
As a result of Pollock's work he was specially mentioned in dispatches, even before the mines were exploded, and was promoted to the rank of Major in recognition of his services on 1 November 1918. Pollock returned to Australia on 3 March 1919 to resume his duties at the School of Physics working on scientific work in acoustics based on his war experiences and worked on the planning of the present Physics Building with Professor Leslie Wilkinson.

Tragically, having survived nearly three years on active service during WWI, Pollock died in Sydney on 24 May 1922 from blood poisoning following a cut to his finger, dying within three days. Hopefully *Beneath Hill 60* will help raise awareness of Pollock's ingenuity and determination to a whole new audience.

References:
Australian Dictionary of Biography – On-line edition
Hermes. Vol XXVIII August 1922
Ever Reaping Something New
Australian War Memorial

ASTROPHYSICIST ELECTED TO AUSTRALIAN ACADEMY OF SCIENCE

Elaine Sadler, an ARC Australian Professorial Fellow and Professor of Astrophysics in the School of Physics at the University of Sydney, was recently elected a Fellow of the Australian Academy of Science.



Distinguished for her work in high energy astrophysics and galaxy evolution Professor Sadler said she was delighted to be a Fellow, "The Academy is a prestigious institution, and to be elected as a Fellow is a great honour for any scientist".

Professor Sadler's main research area is galaxy evolution – studying how galaxies form and change over cosmic time. Currently she says she is busy trying to learn more about the feedback mechanisms which link the energy output of a galaxy's central black hole to global properties like the star-formation rate as well as planning an ambitious new study of distant galaxies which will use the Australian SKA Pathfinder (ASKAP) radio telescope currently under construction in Western Australia.

"In this work, we hope to solve one of the biggest mysteries in cosmology: why did the largest galaxies in the Universe stop forming new stars at least seven billion years ago?"

The Fellowship of the Academy is made up of over 400 of Australia's top scientists, distinguished in the physical and biological sciences and their applications. Professor Sadler is one of four University of Sydney scientists to be made a Fellow. The others are: Professor Roger Reddal (medicine), Professor Jeffrey Reimers (chemistry) and Dr Marianne Frommer (biology).

Professor Sadler said she is looking forward to attending the Academy's formal admission of new Fellows and awards presentation to be held in Canberra on 6 May with her university colleagues. "I do think it's quite exceptional to have three people elected in one year from the Faculty of Science – four altogether from the University of Sydney."

The Australian Fellows of the Royal Society of London founded the Academy in 1954 by with the distinguished physicist, Sir Mark Oliphant, as founding President. The Academy's objectives are recognition of outstanding contributions to science, education and public awareness, science policy and international relations.

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HEADLINE

PROFESSOR CLIVE BALDOCK

It gives me great pleasure to present my first Headline for the new look *Alumni News*. As the incoming Director, Science Foundation for Physics and Head, School of Physics, I am grateful to my predecessor, Professor Anne Green, who served in both roles with distinction.

Both the School and Foundation have achieved a great deal over the years and it was wonderful to meet so many of you at *Honouring Excellence: A Tribute to Emeritus Professor Harry Messel AC CBE*. I'm sure you will agree it really was a very memorable occasion. It was very interesting to learn how Professor Messel changed the culture of the School when he arrived here in 1952 as a young man of 30 years of age. The calibre of the speakers as well as the capacity crowd of alumni and friends certainly made us all realise just how important Harry Messel has been to the development of science not only within the University of Sydney but also throughout Australia and beyond.

The School continues to grow with an increase in the number of undergraduate enrolments and research students so I am delighted that the Australian Federal Government has granted $40million to establish the Australian Institute for Nanoscience within the University of Sydney. The institute will develop nano-devices that will have impacts in many fields including physics, materials science, photonics and medicine. The institute will build research capacity and expand the scope for collaboration with high-tech Australian businesses, leading to direct economic and social benefits.

Coupled with funding from the University of Sydney the old School of Physics Annexe, Building A29, will now be replaced with the new AIN. This will provide additional research laboratories and teaching facilities to maintain our position as the leading Physics departments in the nation and to continue attracting the best and brightest staff and students.

We're also looking forward to the outcome of applications being submitted for funding through the Australian Research Council (ARC) Centres of Excellence (CoE) scheme. Applications for CoEs based in the School have been submitted in Photonics and the Square Kilometre Array (SKA) along with submissions for additional CoE nodes for High Energy and Particle Physics, Computational Neuroscience and Quantum Science.

I am pleased to welcome all new staff to the School including ARC Future Fellow Associate Professor Andrew Dougherty, a theorist from the University of Queensland, and Senior Lecturer, Dr Michael Biercuk, an experimentalist from the National Institute of Standards and Technology (NIST) in the USA. Both members of staff have joined the relatively new and growing Quantum Science research group within the School. You can read more about Dr Biercuk and his colleagues work within this issue.

I hope you enjoy this issue of *Alumni News*.

ROGER – TAHITI!

DR DIANA LONDISH EXPLAINS

If you happen to be in the South Pacific on 11 July 2010 you might be able to witness a total solar eclipse. It will be visible only within a narrow corridor passing just south of the island of Tahiti and right over Easter Island as well as in Mangaia in the Cook Islands (south of the main island, Rarotonga).

A solar eclipse occurs when the disc of the moon passes in front of the sun as seen from the Earth. This only happens during the lunar phase known as the New Moon. Since the Moon's orbit is inclined by about five degrees to the path of the sun across the sky not every New Moon results in a solar eclipse and not every solar eclipse is a total solar eclipse.

By an amazing coincidence the Sun is about 400 times larger than the Moon and the Moon is about 400 times closer to the Earth than the Sun. This means that the size of the Sun and Moon as seen from the surface of the Earth is about the same in the sky. In astronomical terms, the Sun and Moon have roughly the same angular size. This makes it possible for a solar eclipse to occur.

The next solar eclipse visible from Australia will occur on 13 November 2012 and will be visible in the Cairns/Port Douglas area.

FACEBOOKING THE CRITICS

Dr Phil Dooley is the Science Communicator for the School of Physics and President, NSW Chapter of the Australian Science Communicators. Phil has recently started the School of Physics Facebook page, which is receiving plenty of hits. Here Phil discusses the survival of the fittest social communication networks.

"Sell-out!" said the student demonstrator as I intimated I'd started a School of Physics Facebook page.

Is this a sell-out? There are nine million users over the age of 13 on Facebook and over 25,000 of them have specifically listed physics as an interest, so it seems pretty silly to not make use of this new 'revolutionary' technology.

Or is it a revolutionary? I like to think of the Internet as a greatly accelerated survival of the fittest – for every Facebook, Twitter or Google that has caught on, there are a thousand other websites that have not succeeded. The interesting thing, to me, is what makes Facebook the fittest tool.

I think there are two 'revolutionary' aspects to these new tools (call them social networking,

PHD STUDENT IN ASTRONOMY AND THE STARS OF SCIENCE

One of the brightest of the University of Sydney's PhD students, Chris Hales, recently travelled to Lindau, Germany, to meet with over 60 Nobel Laureates and 700 of the world's most promising science PhD and Post Doc students.

Chris who is a postgraduate student with the Sydney Institute for Astronomy, based within the School of Physics was one of fourteen students selected by the Australian Academy of Science from across the nation to take part in the prestigious program, which started in 1951.

Originally the program was limited to German Nationals but the now international program sees students from all over the globe meeting with Nobel Laureates and each other to discuss ideas and make contacts. "I was honoured to be chosen and it was pretty exciting to think I'd be meeting some of these inspirational people in person," says Chris.

"The celebrity suddenly thrust on Nobel Prize winners affords many of them the chance to expand their work and talents into wider society; for example, advising Governments on a wide range of issues, or developing science outreach programs that enable people to learn probabilistic reasoning and to see through widespread delusions."

Chris said it was a wonderful opportunity to be able to interact with and learn from such talented and sometimes outspoken individuals.

A PhD candidate Chris is studying the as-yet

Web 2.0 etc), although the ironic thing is that the concept is not that revolutionary. In fact technology is just mimicking the way we have always communicated more closely.

The defining feature of Web 2.0 is the opportunity to talk back. Posting comments, or even clicking the 'like' button is instantaneous – just like a live conversation! Best of all, Twitter is limited to 140 characters (the same as an SMS message), which forces you to be concise, something all good conversationalists value. The users that 'succeed' are those that promote conversations, rather than a one-way information overload.

Secondly Facebook does achieve what the marketers of our modern world have been aspiring to for years. Savvy marketers know the best way to promote something is not ad campaigns or publicity stunts, it's word of mouth recommendations; Facebook's key is to recommend things to you that your friends like; you trust your friends (usually), they have (mostly) good taste, so the things they like are (supposedly) worthwhile.

Of course there are lots of vapid, time-wasting things to look at on Facebook which sounds like a great reason to add some good solid physics content, to me!

FIND US ON FACEBOOK: **SYDNEY.EDU.AU/SCIENCE/PHYSICS/**

unknown origin of tenuous large-scale magnetic fields that exist in galaxies like our own Milky Way. By understanding their origin, astronomers will be able to better understand the formation and evolution of stars and galaxies within the cosmic history of our Universe.

The annual Lindau Nobel Laureate Meetings provide a globally recognised forum for the transfer of knowledge between generations of scientists. They inspire and motivate Nobel Laureates and international Best Talents. Lectures of Nobel Laureates reflect current scientific topics and present relevant fields of research of the future. In panel discussions, seminars and during the various events of the social programme young researchers nominated by a worldwide network of Academic Partners interact with Nobel Laureates.

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Dr Alexey Kondyurin at the NASA Balloon Launch

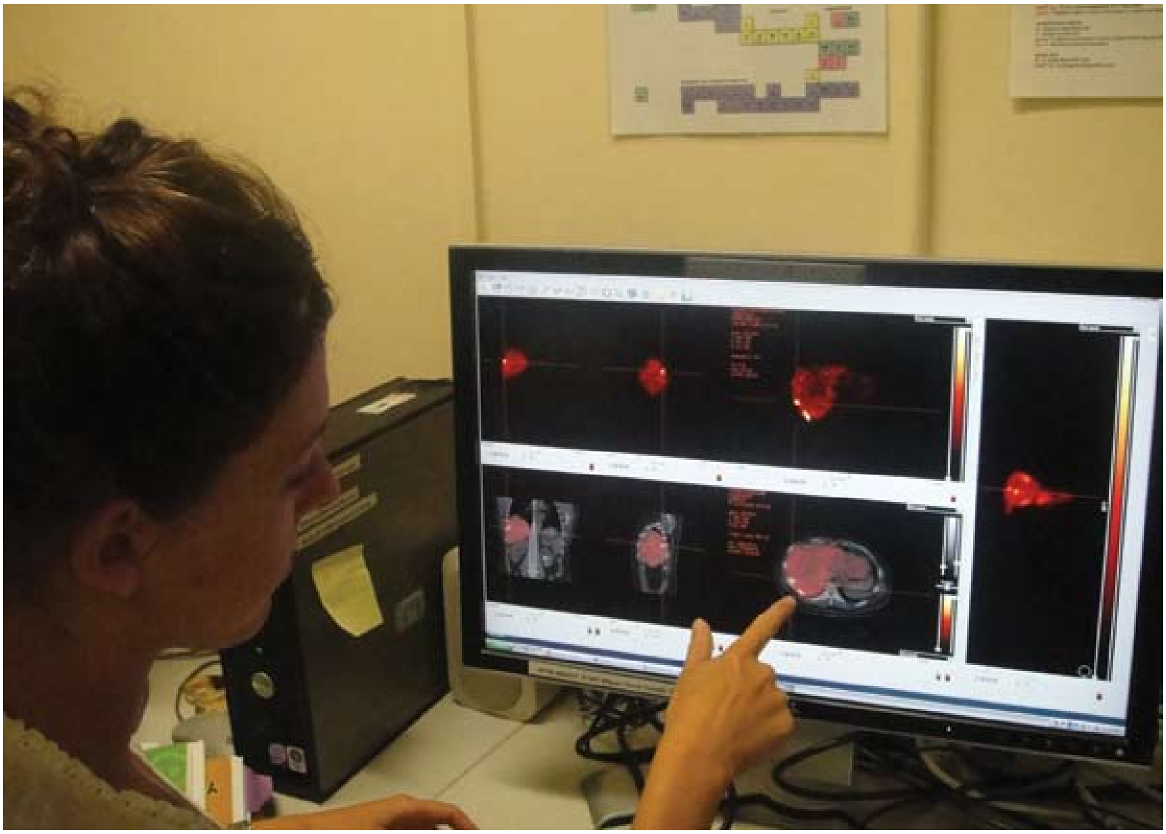
STRATOSPHERIC BALLOON LAUNCH

In mid-April our physicists took part in a multi-million-dollar NASA-sponsored stratospheric balloon mission from Alice Springs. The vast balloon, named Mission 611N, carried onboard an instrument developed by the University of California – TIGRE (Tracking and Imaging Gamma Ray Experiment) that is associated with the cassette of uncured polymer samples developed by the University of Sydney's School of Physics.

Sent into the stratosphere of 40km altitude the goal of the experiment was an exposure of uncured composites in stratosphere. Dr Alexey Kondyurin, a Senior Research Fellow within the School's Applied and Plasma Physics Department, said that the investigation is directed to a development of polymeric material that is curable in space for use as structural components in space habitats.

"Future space exploration will require large light-weight structures for habitats, greenhouses, space bases, space factories and so on. A new approach enabling large-size constructions in space relies on the use of the technology of the polymerization of fiber-filled composites with a curable polymer matrix applied in the free space environment," Dr Kondyurin explains. "Using a balloon means we have access to a unique combination of low atmospheric pressure, high intensity UV radiation including short wavelength UV, diurnal temperature variations and other aspects associated with solar irradiation had a strong influence on chemical processes in polymeric materials. Such conditions cannot be replicated in a lab."

The experiment involved expositing a cassette containing polymer samples to the local environment during the balloon flights. The samples consist of uncured polymer matrix and carbon fibers. The polymer matrix is activated by stratospheric conditions (temperature and sun irradiation) and the chemical polycondensation reaction is initiated. Control samples in the second cassette were kept on ground. After the flight, the samples are analysed by spectral, chemical and mechanical methods. These results will be used for preparation of the space flight experiments on Earth orbit.



Dr Kathy Willowson analysising a scan. The technique involves using the x-ray CT scan to segment anatomical volumes of interest (such as the lungs (left, centre) and liver (right)). The dose to each organ can then be calculated accurately from the SPECT (single photon emission computed tomography – a nuc med functional imaging tool) data which has undergone quantitative corrections following our methodology.

NUCLEAR MEDICINE AIDS LIVER CANCER PATIENTS

Recent graduate, Dr Kathy Willowson, from the Institute of Medical Physics, talks to *Alumni News* about pioneering medical physics research that focuses on improving the treatment of metastatic liver cancer.

"Medical physics really allows you to investigate challenging problems, yet also see how they benefit others. It is a very rewarding area to work in, and it is amazing to see how much physics is behind medicine. When working in the hospital environment, a wide range of clinical problems come up, especially through collaboration with various departments, which makes you realise how broadly such research can be applied.

A major part of this research has been to study patients diagnosed with metastatic liver cancer that cannot be removed surgically giving them have a very short life expectancy. Currently the only available treatment option is palliative, not curative, and consists of Selective Internal Radiation Therapy (SIRT). SIRT involves an invasive procedure where millions of microscopic beads labelled with Yttrium-90 (a beta emitter which is ideal for therapy as it has a short range in tissue) are pumped through a catheter to the site of the liver with the tumour receiving a high radiation dose with the remainder of the body relatively spared.

Yet some radioactive beads can get pushed to the lungs delivering a potentially damaging radiation dose leading to major complications. Any risk that a radiation dose will be too high for the lungs means therapy doesn't proceed and patients have no alternative treatment.

Obviously there's room for improvement. By focusing on the benefits of a full quantitative evaluation of these patients we can calculate how much dose the lungs will receive at therapy then deliver customise therapy doses. This should give a maximum dose to the tumour yet keep the dose to the lungs below an acceptable threshold. This work will hopefully improve the survival times of patients, which is currently only 6-12 months following such therapy.

Much of my research has taken place at Royal North Shore Hospital as part of team in the Department of Nuclear Medicine and working in conjunction with Sirtex Medical, an Australian company, who make the resin microscopic beads used for such therapy. By working directly with Sirtex and combining patient data from multiple hospital sites around Sydney, we have the chance to put this technique into practice with the aim of providing optimum benefits to the patient.

I hope my research will play a role in improving diagnosis in many areas of nuclear medicine, as I see it as a stepping-stone to further work, which I would like to pursue. Quantitative SPECT is a fairly new area that is really only now just opening up due to the introduction of combined SPECT/CT systems. This research will lead to many new possibilities and help address many clinical limitations that currently exist.

Thanks to an Enterprise Connect Researchers in Business Award of $100,000, I'm currently doing a year-long research project specifically on the liver and working directly with Sirtex. I hope that by the end we will have made good progress in stepping towards full quantitative analysis as routine assessment of these patients.

I have to admit though – it's amazing to see how much physics is behind medicine."

IN BRIEF

■ Dr Jong-Wong Kim and recent graduate, Dr Cliff Kerr, based within the Complex Systems Group, have won the 2010 BRAINnet challenge submission by researching a quick method of detecting Attention Deficit Hyperactivity Disorder (ADHD) by studying brainwave patterns. “It’s still has to be refined of course but it takes around six minutes to detect ADHD using our method,” said Dr Kerr. “We hope this means a more accurate diagnosis for patients.”

The joint entry focused on demonstrating that several methods including visual evoked potential mean voltage, de-trended fluctuation analysis and heart rate auto-correlation, show potential use as diagnostics for ADHD.

Based on a simple combination of these methods, a diagnostic measure was developed with a specificity and sensitivity of 75%, results that are comparable to existing quantitative EEG methods, which use far more parameters. These findings warrant further investigation on larger sample sizes where statistical significance can increase and allow refinement and augmentation of the diagnostic method.

IT’S ALL ‘ACADEMIC’

Associate Professor Zdenka Kuncic is the Director of the University of Sydney’s Institute of Medical Physics based within the School of Physics. *Alumni News* caught up with Zdenka and asked her how she balances her busy academic and family life.

Alumni News: You’re married to Professor Geraint Lewis who’s an astronomer in the School of Physics. How do your two young sons respond to having academics for parents?

Zdenka Kuncic: Well naturally, they think it’s normal – don’t all families have professor mums and dads? Of course the likelihood that they’ll follow in our footsteps is remote – I expect they’ll rebel voraciously and become beach bums, or worse still, politicians!

AN: How do you manage to balance work and home life?

ZK: Luckily, academia isn’t restricted by rigid working hours, so there’s really no need to spend long hours at the office – the flexibility to be able to work from home, particularly with research, is really the key to the balancing act. It’s also very important to spend quality “down time” together as a family.

AN: Do you ever find yourself falling into the trap of trying to be a ‘superwoman’?

ZK: What do you mean ‘trying’??! Seriously, kids are the best reality check ever invented – they put everything into perspective and make you realise what’s most important (and least important) in life, so you don’t waste time fussing and stressing over trivialities.

AN: What inspired you to study physics?

ZK: Actually, it’s because I was never really that good at it to begin with! I was always good at maths and science, but I found physics really challenging – I’d get really frustrated by the fact that the answers didn’t always come naturally. But it’s precisely because it’s so challenging that it’s also the most rewarding when it comes to finally understanding a concept and solving a problem.

AN: You’ve got a very interesting area of research – radiation physics – why did you choose that particular field.

ZK: I suppose my research naturally evolved into this area. I started out in plasma physics modelling plasma radiation in space; I then moved to modelling astrophysical radiation processes (mainly photon processes because virtually all astronomical observations rely on collecting photons); I then generalised this to medical applications, which deal with a much broader range of radiation types. I’m motivated by the idea of applying fundamental physics to problems in different physical contexts.

AN: Do you think it’s become easier for women to study physics over the years?

ZK: I don’t think it’s easier as such – the physics being studied is still the same physics – but certainly there seems to be a trend of increasing numbers of women in physics. This is evident even at the HSC level. I’d like to think that this can be attributed, at least in part, to the fading out of the classic nerdy physicist stereotype (I suspect that Mythbusters has helped a lot in this effort!).

AN: Do you and Geraint ever compare research notes while you’re at home?

ZK: No comment!

AN: Finally, any advice for girls who might like a career in science as a researcher?

ZK: Yes – timing is everything.

Congratulations to Paige Miller an ISS2009 scholar who scored an ATAR of 98.2. This achievement was recognised by the University of Sydney awarding Paige a merit scholarship and the Women’s College offering Paige a residential scholarship. Luckily Paige was already familiar with the College. The ISS scholars stay in the Women’s College for the two-week duration of the science school. Paige is now studying a Bachelor of Science

Paige Miller with
Dr Karl at ISS2009

VALE

EMERITUS PROFESSOR JOHN DAVIS 1932–2010

DR BILL TANGO

Little did John Davis realise when he sailed from England to Australia in 1961 with his wife, Madeline, and baby daughter, Christine, that this would become a lifetime adventure in a new and very different land, and that he would become a world leader in the field of stellar interferometry.

The American physicist Albert Michelson first used stellar interferometry to measure stars in 1920. By combining light from two small, widely separated telescopes to produce an 'interference pattern' he determined properties such as the apparent sizes of stars, the separation between two close stars, and other details.

The technical difficulties associated with stellar interferometry were so great that no significant progress was made until the 1950s when Robert Hanbury Brown, then at the University of Manchester, discovered a novel technique that he called intensity interferometry.

John, who was born in London in 1932, had obtained his PhD in 1959 from the University of Manchester's Jodrell Bank Radio Telescope for his research on meteors under the supervision of Sir Bernard Lovell. His future wife, Madeline Parkes, was then secretary to Professor Hanbury Brown.

Professor Harry Messel, then Head, School of Physics, The University of Sydney, had decided to construct a large intensity interferometer. Messel recruited Hanbury Brown from Manchester, and subsequently several other Manchester staff joined the project, including John Davis.

The intensity interferometer was located at Narrabri and the Davis family divided their time between Sydney and Narrabri, where they lived on site in extremely basic accommodation on a property located approximately 20 km out of town.

In 1973 John took the Narrabri data and spent a month at the University of Wisconsin. The Wisconsin group had measured the radiation from the stars in the ultraviolet part of the spectrum using the Orbiting Astronomical Observatory satellite. The sizes measured by the intensity interferometer combined with these ultraviolet observations and ground-based data allowed the temperatures of the 32 stars to be determined. This careful work established the temperature scale for stars hotter than the Sun.

It was an example of the meticulous care John took in analysing and interpreting data. Among John's colleagues it was taken for granted that if he was happy with a result you could be confident that it was correct! As a result the temperature scale result is still the definitive reference in this field.

The work of the intensity interferometer was completed in 1974. During the course of its operation it measured the apparent sizes of 32 stars, all hotter than the Sun. Rather remarkably, if the total amount of radiation from a star that arrives on a square metre at the Earth's surface can be measured for a star, then this can be combined with the size to yield the temperature of the star. This is an 'absolute' measurement in the sense that it does not depend on any assumptions about the nature of the star.

After the closure of the Narrabri instrument John began designing a successor instrument. This was initially planned to be a much larger intensity interferometer. At the same time, however, the whole field of optical science was rapidly changing due to the increasing availability of lasers and other modern optical tools. John became convinced that a better approach would be to return to Michelson's original concept.

To test this John and his co-workers constructed a prototype instrument in Sydney that successfully measured the size of Sirius, the brightest star in the sky. The experience gained with the prototype enabled John, in 1985, to submit a proposal for a large Michelson interferometer: the Sydney University Stellar Interferometer (SUSI).

One of the assessors for the proposal was Professor Allan Sandage, a leading American cosmologist. He wrote "... [I]t is the most significant proposal in stellar astronomy made in the last forty years. The science that can be done...is crucially necessary." This comment referred specifically to the fact that interferometry provides one of the very few ways to directly measure the masses of stars.

The proposal was approved and SUSI was built with funding from both the Federal government and the University of Sydney at the Paul Wild Observatory near Narrabri (the fact that the earlier instrument and SUSI were both located at Narrabri is purely coincidental). It was completed in 1991.

Since then SUSI has been used to measure the sizes of individual stars, the orbits and masses of binary stars and the distances to pulsating stars.

After John retired in 1996 he continued to work with SUSI, initially on a contract basis and later as an honorary staff member. The University had changed greatly over forty years and it was becoming increasingly difficult for staff to spend significant time at SUSI because of teaching and administrative commitments. John, with the help of students, almost single-handedly kept the observing program going, even when his health began to deteriorate.

It was a great comfort to his friends and colleagues that he lived to see two significant changes to SUSI. The first was a change in funding arrangements, which put the operation of SUSI on a sound financial basis. Second, a new generation of young researchers have modified SUSI so it can now be operated remotely from Sydney, greatly increasing its scientific productivity.

In 1979 John set up and chaired a working group on interferometry for the International Astronomical Union (IAU). Although the working group no longer exists in 2006 the IAU established a new Commission on Optical and Infrared Interferometry. He was also vice-president (1985–1988) and president (1988–1991) of the IAU Commission on Astronomical Instruments and Techniques.

John was very modest and he avoided academic politics not seeking honours and publicity. In 2005 he was invited to give the Ellery Lecture of the Astronomical Society of Australia for his outstanding contributions to astronomy. In 2008 a workshop entitled *SUSI: Past, Present and Future* was held in honour of his seventy-fifth birthday.

John's most enduring legacy is perhaps the students that he and his colleagues supervised. John's careful and thorough approach to his work was an inspiration to all of them and they carry on this tradition at observatories and universities around the world.

John is survived by Madeline, his children Christine, Richard and Sarah, his son-in-law Deric, and granddaughter, Ella Rose.

Dr Michael Biercuk and Dr David Reilly of the Quantum Physics Group

SMALLER, FASTER, BETTER, UNIMAGINABLE-ER?

THE QUANTUM REVOLUTION IS COMING

MICHAEL J. BIERCUK, STEPHEN BARTLETT, ANDREW DOHERTY, DAVID J. REILLY
QUANTUM PHYSICS GROUP, SCHOOL OF PHYSICS, THE UNIVERSITY OF SYDNEY

In the 20th century a dramatic upheaval began as classical physics was augmented by the theory of quantum mechanics, operational on the scale of individual photons, atoms, and molecules. The results were astounding; with this new framework long-standing problems in physics were solvable, a new understanding of matter at the atomic scale emerged, and as we all know a new class of technologies founded on quantum mechanics arose.

It is not an exaggeration to say that the modern information economy exists primarily because of the discovery of quantum mechanics. Quantized (discrete) energy levels give us the underlying mechanism enabling the laser – used for high-bandwidth optical communications. Quantum statistics give us the semiconductor band structure used in producing transistors – the fundamental hardware elements in a computer. The phenomenon of Giant Magnetoresistance gives us a way to easily read-out magnetic information – enabling high-capacity, small form-factor hard-disk storage. When one examines nearly any component or functionality in a microprocessor, server, or communications network, quantum mechanics is at the heart of that technology.

As amazing as that is – it's only the first chapter of our story. These technologies and many others exploit only the most basic principles of quantum mechanics – discrete energy levels, the Pauli exclusion principle, and the like. But inherent in the formalism of quantum mechanics was a host of 'quantum coherent' effects that were largely swept under the rug because they were just too strange. For instance – the principle of quantum superposition in which a particle can exist in two or more different states at once, until, upon measurement, the particle winds up in just one of those allowable states. Or quantum entanglement in which multiple particles can be intricately linked even when they're separated by huge distances – any action on one will still affect the other. This is what Einstein famously and pejoratively characterized as 'Spooky action at a distance'.

These phenomena have long been considered mathematical oddities, 'quantum weirdness'. But a new field is emerging looking to explicitly leverage quantum coherence for the development of more powerful and fundamentally new technologies.

Thanks to decades of work in atomic, optical, and solid-state physics we are now able to access the full spectrum of quantum phenomena in a variety of systems – from individual trapped atoms to optical devices, superconducting circuits, and single electrons in semiconducting materials. The strangeness of quantum mechanics is not only being observed in these systems, but it is being controlled, yielding a new discipline – quantum science, founded on the ability to coherently manipulate quantum systems.

Quantum science has the promise to truly revolutionize the modern technology base. In the near term we can expect new sensors capable of using entanglement to provide dramatic performance enhancements over classical technology, novel biomedical imaging techniques giving sub-cellular resolution as well as rapid readout, and new precision time standards for improved global positioning systems. Devices that are smaller and faster, while providing better performance.

But it's not the near term that really excites us; what the future will bring is completely open. When the transistor was invented – the basic logic element in a modern computer – it was believed that it could only be useful for...hearing aids.

At the time, the modern digital microprocessor was unimaginable. The same holds true for quantum-enabled technologies. We just don't know what's down the road, but we can't wait to get there.

DR. BIERCUK, A/PROF. BARTLETT, A/PROF. DOHERTY AND DR. REILLY ARE CONTINUING MEMBERS OF THE ACADEMIC FACULTY WITHIN THE SCHOOL OF PHYSICS. THEY ARE THE PRINCIPAL INVESTIGATORS MAKING UP THE SCHOOL'S QUANTUM PHYSICS GROUP, PERFORMING BOTH EXPERIMENTAL AND THEORETICAL PHYSICS RESEARCH ON THE CONTROL AND MANIPULATION OF COHERENT QUANTUM SYSTEMS.

SCHOLARSHIPS AND PRIZES

THE SCHOOL OF PHYSICS AWARDS $50,000 OF SCHOLARSHIPS & PRIZES ANNUALLY. THANK YOU TO THOSE BENEFICIARIES WHO HAVE CREATED THE AWARDS INCLUDING MRS JAN KING, WHO CREATED THE MALCOLM TURKI MEMORIAL SCHOLARSHIP IN REMEMBRANCE AND RECOGNITION OF HER LATE SON, MALCOLM, WHO'S DEGREE WAS AWARDED POSTHUMOUSLY. MRS KING'S FORESIGHT IS GREATLY APPRECIATED BY THE SCHOOL OF PHYSICS AND THE SCHOLARSHIP'S RECIPIENTS. THANK YOU ALSO TO OUR ALUMNI AND FRIENDS WHO SUPPORT THE SCIENCE FOUNDATION FOR PHYSICS, WHICH PROVIDE SEVERAL OF THESE AWARDS. CONGRATULATIONS TO ALL THE WINNERS FOR 2010 LISTED BELOW.

JUNIOR PHYSICS

The Levey Scholarship No. 1 for Physics:
Benjamin Pope

School of Physics-Julius Sumner Miller Scholarship No. 1:
Chun Chien Shieh, Daniel Jacobs

Science Foundation for Physics Scholarship No. 1:
Alexander Soare, Jiro Funamoto, Viet Tung Vu, Frances Algert, Jason Tsz Shing Yue

Smith Prize in Experimental Physics (shared):
Jiro Funamoto and Daniel Jacobs

Australian Sky & Telescope Prize:
Joseph Callingham

INTERMEDIATE PHYSICS

School of Physics–Julius Sumner Miller Scholarship No. 2:
Alison Hammond, Chun Chien Shieh

Science Foundation for Physics Scholarship No. 2:
Robert Hannah, Dominic Else, Emma Lindley, Matthew Hill, Todd Green

The Slade Prize for Practical Physics:
Alison Hammond

The Geoffrey Builder-AWA Prize:
Anthony Cheetham

SENIOR PHYSICS

Deas-Thomson Scholarship:
David Kedziora

The Walter Burfitt Scholarship No. 2 for Physics:
Barnaby Norris

School of Physics–Julius Sumner Miller Scholarship No. 3:
Barnaby Norris, Romesh Abeysuriya

Science Foundation for Physics Scholarship No. 3:
Graham White, Michael West, Matthew Collins, Vanessa Moss, Timothy Patten

The School of Physics Honours Scholarship:
Paul Stewart, Bjorn Sturmberg, David Webster, Shivansh Kochhar, Matthew Wardrop, Aaron Rizzuto, Samuel Barclay, Francesca von Braun-Bates. Nicola Asquith, Curtis Black

The W.I.B. Smith Prize:
Barnaby Norris

The Malcolm Turki Memorial Scholarship:
Matthew Collins

PHYSICS HONOURS

Shiroki Prize for Best Honours Project in Physics (shared):
James Colless and Casey Handmer

Australian Institute of Physics (NSW Branch) Prize:
Ian Watson

Henry Chamberlain Russell Prize in Astronomy:
Timothy White

POSTGRADUATE PHYSICS

CISRA Postgraduate Physics Prize:
William Corcoran

The School of Physics Postgraduate Alumni Prize:
Andrew Phillips

PAST-PRESIDENT HONOURED

Past-President and long-time Council Member of the Science Foundation for Physics, Dr Peter Jones, was honoured with a Member of the Order of Australia (AM) on Australia Day (26 January). He was awarded the AM for his service to the information technology industry, the promotion of internet-based communications networks and to science education.

Dr Peter Jones AM with Dr Veronica Lambert and Adam Selinger at Rare Science

Peter D. Jones AM BSc BE PhD FTSE, is an Honorary Fellow of the University of Sydney. An alumnus of the School of Physics, Dr Jones' academic career includes positions as Associate Professor of Computing at UNSW, Research Fellow in Computing at the ANU.

He has made a significant contribution to technology within Australia and credits Emeritus Professors Harry Messel AC CBE and John Bennett as positive influences in his choice of career. Jones worked on SILLIAC, a vacuum tube supercomputer, while still a student in the School of Physics in 1956.

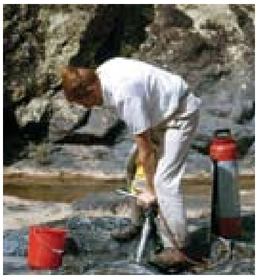
Over the years Dr Jones, who is also a member of ASTEC, the Prime Minister's advisory committee on science and technology, founded a series his own high-tech companies both within Australia and the USA.

Dr Jones was the initial CEO and a founder of ac3 (Australian Centre for Advanced Computing and Communications) at the ATP (Australian Technology Park), and is currently chairman of several high tech Australian owned companies, including Home Communications, Superquant, ETSN, Digital Motion and Ideadata.

In 1998 Dr Jones was awarded the Inaugural Pearcey Foundation Medal for distinguished lifetime achievement and contribution to the development and growth of the Information Technology, Professions, Research and Technology. He also received, in May 2003, the Centenary Medal for service to Australian society in information technology.

Asked about his thoughts on the Internet being used for social communications he said not to expect to find him blogging or on Facebook, "I leave that to my grandkids. It's a whole other world out there now".

The Science Foundation for Physics is Australia's oldest Foundation established by Professor Harry Messel in 1954 to support science research and training within the School of Physics and to promote science to the broader community. Other supporters of the Science Foundation for Physics, Dr Fred Watson AM and Justice Robert French AC were also awarded their post-nominal in Australia Day Honours.



(l–r) Ray drilling for a rock sample during PhD 1966

Ray Research Associate SUNY Binghamton NY 1969

Ray returned from field trip in WA 1976

Ray as CRCLEME CEO 1996

FROM SHOP ASSISTANT TO EMERITUS FELLOW, CSIRO, EXPLORATION AND MINING, WA, RAY SMITH TELLS HIS STORY.

Emeritus Professor Raymond Smith, a Fellow of the Australian Academy of Technological Sciences and Engineering, remembers with fondness the Summer Science Schools now known as the Professor Harry Messel International Science School and granted *Alumni News* permission to re-print part of a personal message sent to Professor Messel that tells his inspiring story.

"When speaking with Brian O'Brien recently, I mentioned how your (Messel's) Summer School in physics on TV in the 1950s had changed my life – from shop assistant to a successful career as a scientist. Brian encouraged me to write to you.

I'd left school in Sydney at 15 years old in 1955. In hindsight I should not have left school. I was working as a shop assistant, doing an apprenticeship in the electrical trades, completely inexperienced and naive about potential careers. I sensed I was going nowhere. Your Summer School TV sessions came like a 'bolt from the blue'. They showed me a wonderful world of science – and I became determined to become part of it.

I enrolled at Sydney Technical College, Ultimo, to do my university entrance. I started my Bachelor's Degree in 1960, enrolled in physics, switching emphasis to geophysics and geology in my graduating year.

After completing my PhD in 1967 (at the University of Sydney), my wife and I headed overseas. This included a year as a Postdoctoral Fellow at the University of Manitoba in Winnipeg, which I think was your hometown.

After a wonderful time in Canada and USA, we returned to Australia. Eventually I joined CSIRO. I loved my research there and 'retired' after some 35 years. For ten years I was a Chief Research Scientist, then appointed to a rare and very special level of CSIRO Fellow in the last four years before retirement.

I mention these career highlights because they all sprang from your original motivation that impacted on me in the late 1950s. Brian and I felt you should know – furthermore, I'm just one of many who have likewise been motivated by your original program. Thank you for changing my life! It has been wonderful and still is!"

EXTRATERRESTRIAL LIFE A TITANIC QUESTION

DR KARL KRUSZELNICKI, JULIUS SUMNER MILLER FELLOW

Way back in 1996, I visited the Jet Propulsion Laboratory in California. I got dressed up in the super-clean bunny suit so I wouldn't contaminate anything, and I was actually allowed to touch the Cassini–Hyugens space probe. It was one of the magical moments of my life.

Cassini–Huygens still holds the record for the largest such spacecraft ever built – 5.6 tonnes, 6.8 metres high, over 4 metres wide, and with over 14 kilometres of cabling. And this was the spacecraft that discovered sand dunes in space! Or, at least sand dunes on the surface of Titan, the giant moon that orbits the ringed planet, Saturn.

When the spacecraft got to Saturn in 2004, it split into two parts. The Cassini part of the spacecraft is still orbiting Saturn doing great science. But, on January 14, 2005, the Huygens part parachuted down to land on Titan. On the way down, its photos showed branching river-beds just like the ones on Earth. And it actually landed on the wet, pebble-littered location of a flash flood.

We now know that Titan has vast deserts with kilometre-high hills circling the equator, giant lakes near the poles, and in between, eroded landscapes with flowing liquids.

Titan is a bit special. It's the largest moon in the entire solar system. At 5000 kilometres in diameter, it's bigger than the planet Mercury, a bit smaller than Mars, and about 40 per cent of the diameter of Earth. Titan is the moon that would be a planet.

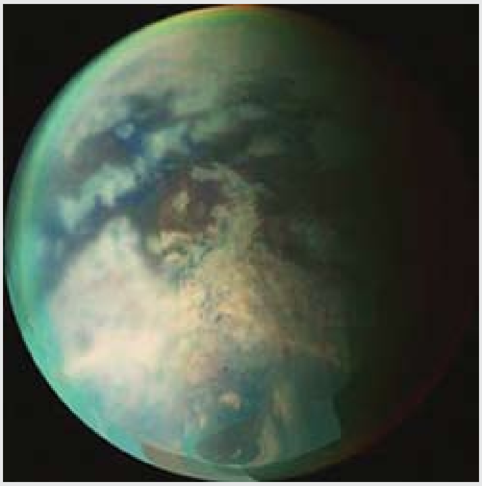
Most of the planets and moons in our solar system have an atmosphere that is either enormous or microscopic, either millions of times thicker than our earthly atmosphere, or millions of times thinner. But the atmosphere of Titan is surprisingly close to Earth's atmosphere – only about 1.5 times thicker.

And the composition of Titan's atmosphere is amazingly close to ours as well. Our earthly atmosphere is about 80 per cent nitrogen and 20 per cent oxygen. Titan's is about 95 per cent nitrogen and five per cent methane.

The sunlight that falls on Titan is about one per cent of the strength of our sunlight, because Titan is so far from the sun. So the temperature is very cold, around $^{-}180$°C. At this temperature, methane, the stuff you burn in your gas stove at home, can exist as a gas, a liquid and a solid.

It sounds just like the situation here on Earth where, thanks to the 'lucky' temperature, water can exist as a gas, a liquid and as the solid that we call ice.

On Titan, methane does the job that water does on Earth. Methane evaporates from the methane lakes near the poles and floats as methane clouds and then drops as methane rain. This methane rain carves out riverbeds and valleys in the surface of Titan, and then flows back into the methane lakes. The shorelines on Titan look like those we see here on Earth.



Titan, Saturn's largest moon, destination of the Cassini-Huyghens spacecraft

The climate sounds similar, but there's a major difference between Earth and Titan. On Earth, the energy from the nearby Sun will evaporate about one metre of water from the ocean each year.

But the Earth's atmosphere will hold only a few centimetre's worth of water before the water turns into clouds and rain. So on Earth, we have a couple of centimetres of water every week or so, dropping as rain out of the atmosphere.

On Titan, the much weaker energy from the distant Sun will evaporate only about a single centimetre of methane each year. But the atmosphere is a giant sponge – it can hold about 10 metres of methane. So on Titan, it's a long time between rains, but when it comes, it's huge.

On Titan, water does the job that rocks do here on Earth. Frozen water-ice under the surface behaves like rock, and brings the overall density of Titan down to about 1.9-times the density of water. We think that Titan has a core of rock and iron, which is surrounded by water-ice compressed to very high pressure.

This ice is, in turn, surrounded by an ocean of water and ammonia, which is then covered with water-ice. And finally we get to the surface, and above that, the atmosphere that is hauntingly similar to that on Earth. But does that mean there is life on Titan? Well, that is a very big question, and I've run out of room!

SCHOOL OF PHYSICS
FACULTY OF SCIENCE

THE UNIVERSITY OF SYDNEY

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