Viruses in the fossil record

Viruses are the most abundant biological entities throughout marine and terrestrial ecosystems, but little is known about virus–mineral interactions or the fossil record of viruses.

Dr David Wacey and Prof. Matt Kilburn from the AMMRF at the University of Western Australia (UWA), along with collaborators from Switzerland, France and Italy, have shown for the first time that viruses can act as sites of mineral precipitation in microbial mats, and in doing so they enhance their own preservation in the geological record. Previous interpretations of ancient nanospheres suggested that they are one of Earth’s most primitive and enduring ecosystems.

The team used a combination of high-resolution microscopy, including scanning and transmission electron microscopy (S&TEM), and the flagship NanoSIMS. They combined this with data on virus genetics to show that viruses occur in high numbers and with high diversity in modern microbial mats from lakes in Brazil. Then, by performing ageing experiments on the microbial mats, which lasted for up to three years, they were able to demonstrate that mineral precipitation took place directly on free viruses and, as a result of viral infections, on cellular debris. The initial minerals that precipitated in the vicinity of viruses were amorphous magnesium silicates. With further ageing they then altered to magnesium carbonate nanospheres of around 80–200 nanometres in diameter. These modern nano-spheres are remarkably similar to enigmatic carbonate nanospheres that are relatively common throughout the geological record. Previous interpretations of ancient nanospheres suggested that they might be mineralised nano-bacteria, bacterial fragments or extra-cellular polymers; now it seems likely that these nanospheres may in fact be ancient viruses.

The ability to identify viruses in the geological record has wide ranging implications because viruses are important agents of genetic exchange and mortality for all life forms, playing fundamental roles in global biogeochemical cycles. Viruses also serve as gene reservoirs that allow their hosts to adapt to changing ecological niches, hence they may have been instrumental in promoting the evolution of early microbial ecosystems on Earth and elsewhere. This research was published recently in the journal Nature Communications.

Flow cytometry helps save the bees

Honeybees have a worldwide distribution and are major pollinators of flowering plants on all inhabited continents. Their agricultural importance as pollinators is very significant, as about a third of our food requires pollination by honeybees. They are also major sources for commercial honey, pollen, and wax production.

The global importance of honeybees for ecosystem stability and human food production is beyond doubt, but they are threatened by continuous devastating declines in populations. Among the major contributors to this global decline are the more than 80 different parasites and pathogens, and the widespread use of pesticides and other chemicals in agriculture. These impact on bee survival and fertility.

Led by Prof. Boris Baer, researchers at the Centre for Integrative Bee Research have collaborated with the AMMRF at the University of Western Australia to develop unique microscopic and flow cytometric methods to rapidly, accurately and quantitatively measure the viability of the honeybee fungal pathogen Nosema apis. The method is also able to assess honeybee sperm viability, of great interest for a local bee-breeding program aiming for better bees.

Cell death is often marked by loss of membrane integrity. The researchers made use of this property to distinguish living cells from dead cells. They used a combination of fluorescent dyes, one of which can diffuse through all membranes and another that can only pass through the compromised membranes of dead cells. Initially validating this approach using fluorescence microscopy,
Flow cytometry helps save the bees (continued)

The researchers then developed and validated flow cytometric techniques that are able to record dye signals of up to 10,000 cells per second with batched data analysis. In order to achieve this, the researchers had to overcome some unique challenges in working with these samples, including determination of the most suitable dye combination for the spores and the sperm. Existing methods, which are optimised for the study of round mammalian cells in the 1–50 micrometre range, had to be adapted to analyse bee sperm, which have a 260 micrometre-long tail. The new methods were found to be more accurate and reliable than fluorescence microscopy for assessing the viability of Nosema spores and sperm. The research has been published in the leading cytometry journal, Cytometry Part A. The new technique can now be used in both research and bee breeding programs.

The ability to rapidly and accurately measure pathogen spore viability will underpin further research to identify the components of bee immunity that can clear Nosema infections. This in turn will enable the identification of therapeutic targets, or the selection of Nosema-resistant breeding stock, for industrial use. Similarly, the ability to measure bee sperm viability is important in bee breeding programs and in the development of pesticides that minimise the impact on bee fertility.

Engineering peptide hydrogels for neural repair

Finding effective strategies for repair of the brain and spinal cord is an important challenge. Ms Kiara Bruggeman in Dr David Nisbet’s group at the Australian National University (ANU) is taking a molecular engineering approach and creating sophisticated biomaterials to act as tissue scaffolds.

Laminin is an important protein that helps guide the growth of developing nerve cells. Ms Bruggeman has built on existing knowledge of how certain short stretches of amino acids (peptides) from laminin, interact with each other. By adding other chemical components to the peptide she has been able to generate self-assembling peptide (SAP) hydrogels. Specifically, the peptide sequence aspartic acid–aspartic acid–isoleucine–lysine–valine–alanine–valine (DDIKVAV) was capped with aromatic fluorenylmethyloxycarbonyl chloride (Fmoc) on the amino-terminus. The aromatic stacking of the Fmoc groups on the ends of the peptides and interactions between adjacent peptide chains cause the self-assembly. The stacked molecules form sheets that wrap into hollow nanofibres with the peptide sequences projecting outwards at high densities. These nanofibres are approximately 10 nanometres in diameter; large enough to offer structural support to growing cells in a similar way to proteins in the natural extracellular environment. While doing so they also present biologically relevant cues to encourage cells to grow and develop properly.

Ms Bruggeman used transmission electron microscopy in the AMMRF at ANU, to confirm that nanofibres were formed, as opposed to other self-assembling structures such as spherical micelles.

The researchers also loaded the SAP hydrogel with brain derived neurotrophic factor (BDNF), a protein that also promotes correct neuronal growth and development. BDNF is unstable in solution and lasts only minutes to hours under physiological conditions. The researchers demonstrated the ability of the SAP hydrogels to substantially increase the lifespan of BDNF. There was sustained release of functional BDNF from the hydrogel for at least six weeks.

The SAP hydrogels are easy to make and biocompatible and have definite potential in the field of neural repair.

Tell us your story!
Contact jenny.whiting@ammrf.org.au

Simon Ringer Executive Director & CEO
International Microscopy Congress (IMC18) in Prague

As well as bidding to win the next IMC meeting for Australia, delegates to the conference itself had much to report. Over 3000 delegates congregated in Prague, Czech Republic, for the six-day conference. The scientific program was huge with eight parallel sessions, and over a thousand posters. There was plenty of networking to be done and many lessons to be learnt about organising and running such a large conference. These will prove very useful in planning for IMC19 in Sydney in 2018.

The opening ceremony included a stunning microscopy-focused light art show and thousands of local school children engaged with microscopy during the conference through the outreach Labyrinth. The entries to the micrograph competition were also a compelling attraction.

It was clear that more and more microscope vendors are building instruments with integrated light and electron microscopy capabilities in one. Correlative light and electron microscopy topics were very popular: it is relatively new and one where we have considerable expertise. It garnered a lot more interest than expected so we should see this field growing considerably in the near future.

Super-resolution microscopy was also featured strongly with a great plenary talk about pushing the resolution of light microscopy to the nanometre scale from Prof. Xiaowei Zhuang.

Australia wins bid to host IMC19 in 2018

Australian Microscopy & Microanalysis Society (AMMRS) President Prof. Martin Saunders, teamed up with AMMRF Executive Director and CEO, Prof. Simon Ringer and Prof. Paul Munro from the University of New South Wales, to lead the bid to attract the next International Microscopy Congress (IMC) to Australia in 2018. Supported by Business Events Sydney, Profs Ringer and Munro presented Australia’s bid in Prague. China and South Korea also presented bids, but Australia won the vote by a large margin.

Many additional AMMRF staff actively supported the Australian bid team and the success is a recognition by leading international peers that Australia has world-class research infrastructure in microscopy and microanalysis and demonstrated leadership in the development and application this capability.

Specialist atom probe meeting in Germany

Before IMC18, a specialist meeting on Atom Probe Tomography & Microscopy was held at the Max Plank Institute in Stuttgart, Germany. This meeting held particular appeal for the AMMRF staff and researchers who use and maintain our flagship atom probe suite. Of the 220 delegates 20 were from Australia.

Over six days the scientific program was a variety of theory, modeling, experiment, data analysis and workshops. There were also opportunities to refresh the brain with trips to the Mercedes museum, highly relevant to the materials scientists at the meeting, and to the local wine festival.

The conference was an opportunity for us to demonstrate our leadership in the field. Our Sydney team was able to spread the word about the recently deployed Atom Probe Workbench component of the Characterisation Virtual Laboratory. They continued to forge connections with the close-knit international atom probe community. As a result we are expecting visits from two high profile atom probeers before Christmas.

National Collaborative Research Infrastructure Strategy (NCRIS) Showcase at Parliament House

A Department of Education showcase was held on 30 September in the Great Hall of Parliament House in Canberra to highlight the success of NCRIS research infrastructure, both as individual facilities and as the whole NCRIS project. It was a good opportunity for MPs, staffs and the public to learn about the extent and diversity of research outcomes that have relied on microscopy and microanalysis.

We were also able to display the Incredible Inner Space exhibition, which proved extremely popular and a great introduction to the AMMRF.

Earlier in September there was also an NCRIS Forum for the Facilities to share information and insights on running successful collaborative research infrastructure.
AWARDS

Innovation award for Microscope-in-a-needle

Prof. David Sampson, Director of the AMMRF at the University of Western Australia (centre, below), and his research team have won the Emerging Innovation Category of the 2014 Mitsubishi Corporation WA Innovator of the Year Awards for their development of the Microscope-in-a-Needle. This highly miniaturised medical imaging device encased in a needle is capable of acquiring microscopic images deep within tissue and has obvious applications for the medical sector.

Prof. Sampson’s work in this area was also recognised by the IEEE who designated him one of their Distinguished Lecturers in Photonics. In this capacity he has been presenting lectures on his Microscope-in-a-Needle work to researchers in Europe, North America, Asia and Australia.

CAPABILITY

ARC grants support growing capability

In the latest round of Australian Research Council Large Infrastructure, Equipment and Facilities (LIEF) and Discovery grants there have been some notable successes for the AMMRF and its users. Our node at the University of Western Australia (UWA) won a LIEF grant to buy an ultrahigh resolution dual beam to provide 3D imaging, site-specific analysis and nano-machining to researchers in the geosciences, engineering, biological and physical sciences. UWA will also be acquiring a mass-cytometry-by-time-of-flight instrument that marries the resolution, specificity and sensitivity of atomic stable-isotope mass spectrometry to the high-throughput, single-cell analytical advantages of flow-cytometry. This will make it possible to advance understanding of the diversity of cell phenotypes and functions within a systems-biology approach.

The University of Queensland also had success under LIEF with a grant for direct electron detection cameras for their flagship high-resolution transmission electron microscope (TEM). These cameras are a recent technological breakthrough delivering one of the greatest single advances to the field of molecular cryo-EM. This will offer unique and significantly improved capabilities for atomic resolution protein structure analysis.

In looking through the list of awarded Discovery Project grants, major users of the AMMRF feature prominently and we will be pleased to continue providing microscopy solutions to support their research.

STAFF NEWS

Dr Yingying Su

Dr Yingying Su has recently joined the AMMRF team as Senior Light Microscopist in the Australian Centre for Microscopy & Microanalysis (ACMM) at the University of Sydney (UoS).

Dr Su completed her PhD in structural cell biology with A/Prof. Filip Braet at the UoS. She went on to work as confocal microscopist in Brain & Mind Research Institute and as microscopy officer in the Bosch Institute Advanced Microscopy Facility for two years before she joined ACMM.

She is looking forward to the upcoming challenges and opportunities that come with expansion of the ACMM to include the Cellular Imaging Facility at the Charles Perkins Centre. She will help to keep our users at the cutting edge.

Autofluorescence wins a place in Nikon Small Worlds competition

A/Prof. Paul Rigby from the AMMRF at the University of Western Australia has an image in the top ten of this year’s Nikon Small Worlds photomicrography competition. This large international competition is now in its fortieth year celebrating light microscopy. The top images will feature in the 2015 Nikon calendar – perfect timing to celebrate 2015 – the International Year of Light.

A/Prof. Rigby’s image of an unfixed petal from a Gaillardia grandiflora shows hairs on the petal surface. On the edge of the petal are a number of pollen grains (blue) surrounded by fungal hyphae (yellow and dark filaments). The image has no staining, relying solely on autofluorescence. It is a maximum intensity projection of a confocal microscope Z stack (34 slices at 8mm z steps). Autofluorescence was collected in four separate detectors and combined to give a ‘natural colour’.

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