PLAGUE OF JUSTINIAN INVESTIGATED

- THE FIRST YERSINIA PESTIS PANDEMIC IS GIVEN THE MODERN GENETIC AND BIOINFORMATIC TREATMENT

Yersinia pestis, a bacterium with a rat reservoir, has caused at least three human pandemics – the Plague of Justinian (6th-8th centuries), the Black Death (14th-17th centuries) and the third pandemic (19th-20th centuries). Genetically speaking the first pandemic has remained un-characterised. That is until a recent investigation completed by an international team of scientists, including Professor Eddie Holmes from the School of Biological Sciences.

Plague DNA from the teeth of two victims buried in a graveyard in Germany was extracted and amplified for analysis. This was no easy feat given how degraded centuries-old DNA becomes. “This is a great example of what can be done with all this new sequencing technology,” Eddie said. The advances in ancient-DNA techniques led the scientists to some interesting conclusions about the pandemic.

“We discovered that the bacterium responsible for the Plague of Justinian, which jumped from rats to humans and killed many millions of people in the sixth century, faded out on its own,” said Eddie. That is, the strain of Y. pestis which caused the Plague of Justinian was different to the strain which caused the Black Death and the third pandemic. It was also different to any modern strains that are still present in wild rodent reservoirs, but closest to those found in China. This, suggests the researchers, means that the Plague of Justinian probably emerged from China. Nowadays rodent Y. pestis reservoirs are found in North and South America, Africa and Asia.

“This study raises intriguing questions about why a pathogen that was both so successful and so deadly died out,” Eddie said. The team, led by researchers at McMasters University in Canada, analysed the Y. pestis genome for clues as to why the Justinian version was so virulent but no obvious differences were found. “One possibility [to why the pathogen died out] is that human populations evolved to become less susceptible.” This possibility is somewhat comforting.

However the authors of the Lancet Infectious Disease paper ended their article on a cheery note, with the observation that the pathogen responsible for killing nearly half the world’s population remains capable of ‘spilling over’ again into humans – “as they have repeatedly in the past.”
What fun we had at last October’s alumni social, *Back to School*, showing off some of the new technologies we currently use in our teaching labs! I was impressed with the enthusiasm and remarkable skill with which graduates of plant anatomy produced beautiful sections of plants. Meanwhile they were thrilled with the quality of the digital images of their sections taken using our new microscopes. Cutting sections must be like riding a bike – once you master it you will always have the skill. I encourage you to take a few minutes to look at the images from this day – they are available at the School’s webpage in ‘photo galleries’ under the ‘alumni’ button. sydney.edu.au/science/biology/alumni/photo-galleries

We are already planning for the 2014 Alumni social scheduled for Saturday 25th October so please save the date. This will be a sit-down dinner and our plan is to have as many as possible of our academic staff, both past and present, to attend to give our alumni an opportunity to reconnect with their lecturers and supervisors.

Associate Professor Peter McGee, our mycologist for nearly 25 years, retired at the end of 2013. I join with the students and staff of the School in thanking him for his major contributions to the School over this past one quarter century. He has been a leader in challenging undergraduate students to think independently and, on the research front, in forging new ways of studying carbon in the soil.

On a sad note, Professor Alan Walker FAA passed away in October last year. He was a member of the School from 1967 to 1993 (including two years as Head of School) and served on the University Senate for a period. Many alumni will recall his lectures on cell bioenergetics and biophysics. Alan was an international leader in plant membrane transport and he will be missed by his many colleagues here and around the world.

Our alumni are spread far and wide and this newsletter highlights two of them. Dr Michael Kearney, who did his PhD in the School under the supervision of Professor Rick Shine, currently holds an academic position at the University of Melbourne. Dr Kearney will deliver our 2014 Keast Lecture on Friday 16th May and you are cordially invited to attend (see back page). Dr Fiona Cameron did her undergraduate studies in the School in the early days of molecular biology. You can read the interesting tale of how she came to a position as an Executive Director at the Australian Research Council in our Alumni Profile on page 7.

I hope that you enjoy reading this newsletter and I look forward to seeing you at one of our alumni events this year.

Best wishes,

Robyn Overall
RESEARCH SPOTLIGHT: NATHAN LO

You approach the cockroach with caution. You raise your thong and...splat! Ewww! Now look closer at the mess smeared on the floor. In particular, look at the white stuff or ‘fat body’. It is the contents of the fat body that may be the chink in the cockroach’s armour.

“The fat body contains three main types of cells – cells that contain fat, cells that contain uric acid and cells that contain Blattabacterium” explained Associate Professor Nate Lo. It is these Blattabacterium which have caught Nate’s interest and may eventually lead to a target for pest control.

“The bacteria live symbiotically in all cockroaches and one species of termite,” he elaborated. “The symbiosis in this case is obligate mutualism – where the two partners need each other to survive.” This generates some challenges, as the bacteria cannot be grown in culture outside the host. “The bacteria were discovered a century ago but very little was known about them.”

However, Blattabacterium genomes from several species have now been sequenced, including the wood-eating cockroach (Panesthia angustipennis) and the Giant-Australian termite (Mastotermes darwiniensis), both completed by Nate and his collaborators. These genomes have begun to reveal the nature of this symbiotic relationship.

“It was believed that the Blattabacterium was recycling uric acid by turning it back into amino acids.” This is very useful for cockroaches and termites as their diet typically contains low amounts of nitrogen. “Animals usually can’t recover their waste nitrogen, so they need a bacterial helper.”

“But once we sequenced the Blattabacterium genome we saw that there was no enzyme for breaking down uric acid.” This was a surprising discovery, however they did find genes that can turn urea (a breakdown product from uric acid) into useful amino acids.

“The mystery is now ‘how does the host turn uric acid into urea?’ And to answer that we are going to look for evidence of uric-acid-degrading enzymes in the cockroaches.”

Nate thinks that there might be some practical benefits to understanding these interactions. “If you are able to stop the bacterium from giving the amino acids back to the host then that is a problem for the cockroach.” This would essentially be a targeted pesticide. “The more specifically we target the interaction, then the less likely it is that there will be problems for humans or other animals in the environment.”

The story now takes an unsavoury turn, as we look at what the Blattabacterium can tell us about cockroach evolution.

“The ancestor of all cockroaches, which existed about 150 million years ago, was infected by Blattabacterium. It has been a very long relationship, with the bacterium being strictly transferred from mother to offspring.” But, I hear you ask, what about that one species of termite which also contains Blattabacterium? Well, during his PhD, Nate found that termites are actually a form of cockroach, in the same way that humans are a form of ape. But that’s not the unsavoury bit.

After sequencing the bacterial genomes Nate found that the Blattabacterium genome from the Giant-Australian termite was significantly smaller than the cockroach Blattabacterium genomes. “Many of the essential amino acid pathways have been lost. So while cockroach Blattabacterium genomes have eight pathways for essential amino acid production, in the termite about six of these have gone.” Still not the unsavoury part.

Essential amino acids are so named because the body cannot make them itself. Therefore, in the termite, something else must be producing them. The answer lies in their guts and their social nature. “Termites have evolved a very complex and diverse gut fauna and it is these bacteria which produce essential amino acids.” And the sociality of termites, which is different to the solitary nature of cockroaches, means that termites feed their young and each other. Ok, now the gross bit.

“Termites feed each other via proctodeal trophallaxis,” said Nate, chuckling a little. In layman’s terms, that means anus to mouth. “This ability to share means that they conserve nitrogen.” The Giant-Australian termite is the only termite to have Blattabacterium because it is the most primitive. All other species of termite are more socially advanced, “so their ability to share fluids has probably increased and is more efficient.”

So look again at that cockroach squashed under your shoe and think, ‘at least it doesn’t share poo.’
LONELY CHAMELEONS ARE DULL AND SLOW

BY VERITY LEATHERDALE

One of the first studies conducted on young reptiles reared without contact with their siblings is challenging the assumption that only mammals and birds are shaped by social interactions.

“These chameleons use dramatic colour changes to signal dominance,” explained Cissy Ballen, a PhD candidate in the School of Biological Sciences and lead author of the paper published in Animal Behaviour. “The lizards raised in isolation were more submissive and displayed darker and duller colours than those raised with their siblings.”

Further, Cissy also found that the chameleons reared in isolation were slower at attacking certain food. “Our results demonstrate that rearing these animals in different environments strongly affects their social development.”

The research was conducted using young veiled chameleons (Chamaeleo calyptratus), large tree-dwelling lizards native to Yemen and Saudi Arabia that are popular as pets and in zoos. While their mother usually leaves after giving birth, they often encounter their brothers and sisters as they grow up. In Cissy’s experiment, the chameleons were raised alone or in groups of four.

In addition to their slower food attack times and duller colours when young isolated chameleons had contact with siblings, they fled and curled into balls. In contrast, those reared in groups interacted and exhibited their colours in a competitive display.

“Young chameleons, like many reptiles, often engage in intense combat with each other. The absence of this opportunity appears to slow the development of behaviours that help the lizard intimidate rivals and succeed in acquiring food.”

Until very recently, scientists had believed that only the ‘social’ species, such as birds and mammals, were disadvantaged by being reared in isolation.

Early research assumed that reptiles’ behavioural traits were highly stereotyped and fixed, differing between species but not changing in response to the conditions that an individual experienced during its lifetime. However, there is emerging evidence of complex social systems among some lizards, including the ability to solve cognitive tasks, exhibit social learning and demonstrate specific variations in mating behaviour.

“The idea of lizards as machine-like creatures who do not respond to local conditions is being replaced by a new appreciation of the subtlety and flexibility of reptile behaviour as influenced by their local environment and genetic factors,” said Cissy.

“Our results also have obvious implications for the captive rearing of reptiles. These animals are commonly raised by zoos, private keepers and pet owners in social isolation, under the assumption that social cues are irrelevant to their development. Our results call that into question and suggest that for many reptiles, an environment rich in social interaction may provide important benefits for their wellbeing.”
AFTER THE FLOODS COME THE RATS

BY AARON GREENVILLE

They ate the supplies belonging to Burke and Wills, and more recently chewed on the electrical wiring throughout homesteads. They have even disrupted communication networks. A rare invasion of native rats that spreads out across central Australia, holding siege to some of the remotest and driest regions of our country.

Once every ten years or more conditions change in central Australia and flooding rains fall across the desert. The desert blooms and turns a vivid green – such a contrast against the red sand and the deep blue sky. A mass seeding event takes place as grasses pour out their life boats in hope of more rain. These are the conditions the long-haired rat, otherwise known as the plague rat (Rattus villosissimus), takes advantage of.

The long-haired rat feeds on seeds and vegetation, but also anything else they can get to. If camping in central Australia this rat is known to eat all the paper labels off your tins and even have a go at your swag – it doesn’t matter if you are still trying to sleep in it!

Given the conspicuous nature of the rat, it is surprising that we know little about its biology. Thus we set out to find out more. In our study published in the Greening of arid Australia: new insights from extreme years, a special issue of Austral Ecology, we collated historic, media and anecdotal records to work out if we could predict when this rat may irrupt. We found there was an eighty-percent chance of a rat plague following a flooding annual rainfall of 750 mm. To put that in perspective, central Australia has an average annual rainfall of 150-200 mm.

But where do the rats come from in the first place? They are quite rare in the dry times and disappear from much of the desert. Are they holding out in one or multiple hideaways? A 1972 study suggested a single refuge in the Barkly Tablelands. To investigate this we set up live-trapping grids at twelve sites. If the rats have only one safe-house, then they would move in one direction from the north. But the rats came from the south! We also found greater captures at trapping grids closer to drainage lines. This suggested that other refuges exist and that drainage lines provide important corridors for dispersal.

Even though the long-haired rat can be an inconvenience to some, it has some interesting biology. Perhaps, in another ten years time we can find out some more.

Originally published online at aarontheecolog.wordpress.com/

VALE ALAN WALKER

Professor Norman Alan (Alan) Walker FAA, who joined the School of Biological Sciences in 1967 and retired as Challis Professor of Biology in 1993, passed away on 28 October, 2013.

Alan made major contributions to plant biophysics and our understanding of transport across plant membranes. Early in his career, he was involved in the development of the technique still used today to measure the electrical potential difference across plant cell membranes. He went on to characterise the mechanism of transport across the cell membrane of all the major ions and compounds needed by plant cells. With collaborator Alex Hope, he developed a quantitative explanation for the electrical potential difference across the plant cell membrane and with Andrew Smith made the first measurements of cytoplasmic pH in plant cells.

Alan served on the University Senate (1986-87) and as Head of the School Biological Sciences for two years. Alan leaves a legacy of plant scientists around the world who have been mentored and inspired by him. He was admired for his high intellectual rigour, integrity and insatiable curiosity. A very special person - he will be missed by his family, friends, colleagues and the field of plant biophysics.

Photo by Aaron Greenville

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Photo by Aaron Greenville
FAREWELL PETER McGEE

Peter, who joined the School in February 1989, retired in December of last year. He requested ‘no fuss’ at his farewell, but such long and dedicated service cannot go unacknowledged.

Peter made major contributions to both the School and the University in the areas of research, teaching and administration. In research, Peter made substantial contributions to the field of mycology, including his work on soil remediation and soil carbon. “Peter’s research has been marked by outreach to industry and the community,” said Professor Robyn Overall. “He will be missed by us, and more broadly in his discipline.”

“One of Peter’s strengths is his ability to see where lab experiments can be translated to the field and beyond,” said Dr Jenny Saleeba, senior lecturer in the School. “Peter and I had many stimulating conversations that covered everything from theoretical aspects of biology through to field experiments and industry application.”

In teaching, Peter was one of the earliest to use student-centered learning and independent projects. He cultivated critical thinking in his students.

“Peter was a wonderful teacher and loved to teach and made a huge effort to be a good teacher,” exclaimed technical officer Dr Anne-Laure Markovina. Peter’s teaching and mentoring also extended to staff within the School. “As a mentor Peter always encouraged thinking outside the box,” said Anne-Laure. “When I first started to work in his lab he said to me You’re asking me to be God! By that Peter meant that he didn’t have the answer to everything I was asking!”

“I thoroughly benefited from working under and alongside Peter in the last few years,” said former PhD student, Dr Tom Mugerwa. “Peter had a unique approach to research. An approach that I believe brought the best out of his students and colleagues.”

At his farewell Peter said “I’ve had an incredibly privileged existence. And my advice to our current students is to seriously think about having a career in academia. As an academic, you are in charge of your own destiny.”

The School of Biological Sciences thanks Peter for all his contributions and hopes he will enjoy having more time to pursue your other interests... like swimming, yoga, art, history and photography!
Dr Cameron is the Executive Director for Biological Sciences and Biotechnology at the Australian Research Council (ARC) - one of the major granting bodies for University based research in Australia.

In this role, Dr Cameron also carries out some of the ARC’s lesser known functions including policy advice to government, research advocacy and promoting research capacity.

Biology News caught up with Dr Cameron to explore her path through research, developing Intellectual Patents (IP) and into a senior role in the public service.

What drew you to Biology and gene research?
In high school, studying for my biology exams, I learned about the carbon cycle and was fascinated by the journey of carbon atoms during biological processes. Ultimately however I was captivated by DNA and the link to genetic outcomes through the generations and I pursued that into my undergraduate studies.

What are your memories from the School of Biological Sciences?
My favourite of the three genetics topics in third year was far and away the molecular biology component with Keith Brown. Genetics was not a popular subject at the time and we started the year with eight people in the class, so it was quite intimate.

At the very first lecture, Keith appeared in shorts and sandals (or they might have been thongs) and his first words were “about this 9am lecture, how about you all get your timetables out and we shift it!” (which we did).

I also have strong memories from population genetics of separating out the virgins on a hot summer’s day in the upstairs Drosophila lab only to have a bottle of ether explode due to the heat (fortunately on the back bench). And of course a (very) hazy memory of a ‘compulsory’ weekend up at Pearl Beach.

What was the research work you did at CSIRO and Macquarie University?
I started at CSIRO as a visitor while employed at the Royal North Shore Hospital. CSIRO had kindly allowed me to do my Sanger sequencing in their labs. It turned out to be a more difficult gene than anticipated and in an interesting turnabout, I identified a sequence responsible for a new system of moving antibiotic genes around, now known as an ‘integron’.

Although I had finished my degree several years earlier I was inspired by this discovery to start my PhD. I was fortunate to win a Wool Industries Postgraduate Award and to find a supervisor up the road from CSIRO at Macquarie University, while still able to work on site at CSIRO. This was when I shifted from prokaryotic to eukaryotic genetics and studied gene control in mammalian cells utilising antisense molecules. I also made the first demonstration that ribozymes, discovered in plants, were active in animal cells.

Much of your research was commercially funded, how did that change the direction of your work?
My later research in Gene Therapy at CSIRO was commercially funded and this meant that the direction of the research was more clearly defined than in the past. However the research was at the cutting edge and we were constantly ‘pushing back the frontiers’. The downside, was that it was very difficult to publish papers, both because of the punishing deadlines and for the need for ‘commercial in confidence’. Currently the filed patents on gene delivery molecules and formulations are most of what I have to show for that period, and the likelihood of my publishing the rest of the work is slowly diminishing with time.

Your role at UWS involved IP development. What are some of the challenges with commercialising discoveries?
At UWS I was responsible for identifying and making the most of research discoveries from all fields in an applied translational sense.

Finding a licensing partner for a completed discovery can be very difficult, like finding a needle in a haystack. A much more fruitful path is to engage with a potential licensing partner much earlier in the research process and develop the invention collaboratively. That way the invention has a built in path to market and a much higher chance of successful translation.

How did you become involved with the ARC?
My involvement with the ARC was one of those circumstantial things where I saw the job ad while looking for something completely different and realised that my circuitous career path through CSIRO and the university system meant that the job criteria looked to be a perfect fit. Fortunately the ARC thought so too, and I have embarked upon my next career, a public servant, with the lucky position of connecting regularly with Australia’s top researchers and research administrators.
EVENTS

KEAST LECTURE - FRIDAY 16 MAY 2014

The Thermodynamic Niche - physiologically based models of climatic constraints on animals

Not too hot, not too cold, its just right! Climatic constraints are not just applicable to Goldilocks. Climate influences the distribution and abundance of animals in a rich variety of ways. Most directly, it imposes constraints on heat, water and nutritional balances.

In the 2014 Keast lecture, Dr Michael Kearney (University of Melbourne) will discuss the sum of these constraints, the 'thermodynamic niche', and how it can be characterised using integrated models of the biophysics of animals and their microclimates, together with metabolic theory.

VENUE: DT Anderson Lecture Theatre, Heydon-Laurence Building, Science Road.
TIME: 1:00pm-2:00pm, with lunch to follow
REGISTRATION: biorsvp@sydney.edu.au

BACK TO SCHOOL ALUMNI PARTY 2013

Alumni found themselves back in the Biological Sciences teaching labs last October for our annual social. During the party alumni explored the new equipment used by our current students for the study of microscopy, phylogeny and experimental physiology. Many of the photos taken with the microscopes and several others from the evening can be found on our facebook page www.facebook.com/sydneybiology/photos_albums
An alumni dinner is in the planning for 2014, so please save the date for Saturday 25th October at 6pm.