ABC

HD **Anzac Girls 2014 - at a space camp near Gallipoli**

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After its 10-year journey, Rosetta nears comet 67P

Space Camp for school students boosts interest in physics, astronomy, maths, history

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Birds get lucky after prolonged lack of sleep

Germaine Greer rehabilitates her patch of SE Qld

How the body recognises viruses

Soil amoeba reveals clues behind human disease

Algae show promise in supplying proteins for vaccines

Robyn Williams: Michael Brooks who writes for the New Scientist put it this way: 'Rosetta is important. In an era of fatalistic acceptance of humanity's shortcomings, the Rosetta team reminds us of what we can achieve.'

The Science Show on RN. And we start with an update of that spacecraft closing in on a comet, 400 **million** kilometres out in space. Stuart Gary reports.

Stuart Gary: Images taken by the Rosetta spacecraft show the four-kilometre wide comet is starting to develop a distinct envelope of gases which will eventually diffuse out to become the comet's characteristic coma and tails. It's taken Rosetta over 10 years just to catch up to the comet. The spacecraft has been around the Sun four times and undertaken four gravity assists, using the Earth and Mars as slingshots to increase its speed just enough to catch up with 67P. Astronomers hope the Rosetta spacecraft will unlock the secrets of comets, in the same way that its namesake, the Rosetta Stone, allowed archaeologists to unlock the secrets of ancient Egyptian hieroglyphs.

Comets are older than the Earth. In fact they are the builders' rubble left over from the formation of the **solar** system 4.6 **billion** years ago. Astronomers hope Rosetta and its tiny lander Philae will tell us about the conditions and materials around when the **solar** system was born. Avionics systems engineer Warwick Holmes who helped build Rosetta says the spacecraft is now safely in a controlled powered orbit around the comet.

Warwick Holmes: The objective now is to continue flying in front of the comet, doing a triangular orbit, an equilateral triangle, each length is about 100 kilometres long. The purpose of that is to stay in front of the comet and to map the surface of the comet as it's rotating underneath us. And over the period of the next few weeks we will be reducing the size of that triangular orbit and getting closer and closer to the comet itself, until we get to a point about 10 to 20 kilometres above the surface where the very, very slight gravitational force of the comet, the orbiter, will we hope go into a closed orbit where we won't have to use the thrusters anymore.

Stuart Gary: Comet 67P has been full of surprises already. Images taken by Rosetta back in May showed the comet, then still over 600 **million** kilometres from the Sun and well beyond the snow line between the orbits of Jupiter and Mars where it's still cold enough for most chemicals to remain frozen, had already started to come alive. That's much earlier than scientists expected. Luckily images taken just a few weeks later showed things appear to have quietened down again, with 67P appearing to re-enter a dormant phase.

The return to dormancy is good news for Rosetta scientists. They want to study the comet at close range as it transforms from a mountain of ice and rock, frozen solid by years in deep space, to an active dynamo spewing jets of debris into a magnificently evolving coma and tails. And it looks like researchers got their wish in the latest images showing the comet is now slowly starting to awaken. Images show the on-again - off-again gas streams are on-again, and this time with more heat from the Sun warming things deep inside the comet, the sublimating gas is likely to stay on and keep increasing.

Yet another surprise for scientists were new Rosetta images showing 67P is not a single body but actually a contact binary, two comets that have melded together. Contact binaries are thought to originate went two smaller comets become gravitationally attracted to each other through a process called accretion. It's the same process which built asteroids and planets. According to Holmes, the fact that 67P is a binary adds to the complexity of the spacecraft's orbit.

Warwick Holmes: The fact that it is, we believe it to be a binary comet, will have an effect on Keplerian orbit in the sense that there will be a wobble induced in the orbit by these two bodies rotating around their centre of gravity. It just makes things more difficult. The other issue we have to begin to worry about is the comet becomes more active as it's approaching the Sun, and then we have to begin to map carefully the sites where the gas and dust are being ejected. And there will be an attempt to avoid these sites if they become too active.

Stuart Gary: 67P has a dark, dusty crust with a bizarre landscape of steep precipices, sharp protruding crags and strange broad pits. This alien vista was formed by volatile gases tearing out from beneath the comet's surface during one of its many past encounters with the sun. If all goes to plan, Rosetta will descend to an altitude of about a kilometre above the comet's surface on November 11 and deploy its small landing craft, Philae.

Warwick Holmes: That's going to be the absolute highlight of the whole mission, if we can successfully get that lander down. It's looking really, really complex now. The surface is extremely rough. So as we are coming down, with the gas and the dust jets and the oscillation in the gravitational field, a very small gravitational field, that will actually move us around as we are coming down with the lander, and there's an uncertainty of exactly where we are going to touch down. We will fire two harpoons into the surface. On each of the feet there's what we call an ice screw which is a twisting mechanism which is using the kinetic **energy** of the lander to screw the feet in as well.

Stuart Gary: Why do we want to land on a comet?

Warwick Holmes: Well, it's the chemistry on the surface, Stuart, which is the Holy Grail. There have been flyby missions and there has been an impacter into a comet, but even the ejection of the material from the surface is being modified by the ultraviolet of the Sun and the heat of the Sun. So the Holy Grail is to land on the surface and get below the surface and to pull up pristine material from the absolute origin of the formation of our **solar** system.

Stuart Gary: Rosetta and Philae will study 67P for 17 months as its orbit takes it around the Sun, before heading back out into deep space. The comet will reach perihelion, the closest point in its orbit around the Sun, in August next year. It will sweep around the Sun at 135,000 kilometres an hour before heading back on its continuing six-year elliptical orbit.

Robyn Williams: Stuart Gary on Rosetta. His StarStuff website went up again this week. Check it out.

Anzac girls now, with a difference. Amina Harati-Farrow is in year 11, and Iman Noufl is in year 10 at Wiley **Park** Girls High School, Sydney. They've just been to Turkey, and not only to Gallipoli but to a Space Camp. The prompt came from Jackie Slaviero, Space Camp ambassador, and was backed by Wiley **Park** principal Maureen Davis.

Here they are with science teacher Murray Henstock. And we start with Jackie.

Jackie Slaviero: I've taken more than 100 students to Space Camp USA and I heard there was Space Camp Turkey, so I went to Turkey and I was the first Australian ever to go to Space Camp in Turkey, that was about three or four years ago.

Robyn Williams: Okay, space camps in America you'd imagine. How come Turkey though?

Jackie Slaviero: The man who owned the facilities **company** for the Aegean Free Zone, his children went to Space Camp USA, and it was such an inspirational thing for him that he decided he wanted to open one in Turkey.

Robyn Williams: And the Turkish helped?

Jackie Slaviero: Yes, the Turkish government owns the Aegean Free Zone, so it's actually placed in there. You go along and there's all industry and then all of a sudden there's Space Camp sitting in the middle of it all.

Robyn Williams: The advantage of course is you've got all the ancient history around you which you can explore at the same time.

Jackie Slaviero: The biggest advantage is going to Gallipoli, so going not just to Turkey to see how beautiful it is and the ancient ruins, but also our really, really strong links with the Turkish people and our links with Anzac.

Robyn Williams: So you went to Maureen, the principal of the school, and you said, what?

Jackie Slaviero: I said, 'Maureen, I have 12 scholarships from the Global Friendship Fund for students to go to Space Camp Turkey, are you crazy enough to help me and come with me? Do you want to do this crazy idea?' And she went, 'Yes!'

Robyn Williams: Did you?

Maureen Davis-Catterall: I certainly did, what a fantastic opportunity. It's there on a plate, that our girls can go to the other side of the world, experience the wonders of the world, science, maths, physics, with what's in Space Camp Turkey, and Gallipoli as well. So yes, definitely worth a go.

Robyn Williams: Before there was Turkey and Greece, the whole region of course was the place where some of those ideas were fostered.

Maureen Davis-Catterall: Well, the days before we went to Space Camp we had a tour guide who was a 70-year-old gentleman who was very knowledgeable who brought in all of the history and talked about what came first with Istanbul etc, with maths and the world. It was fabulous. He had all of the girls totally engaged. They didn't realise that they were walking six and seven hours a day in the heat, 34-degree heat. Yes, it was extremely engaging, it was wonderful.

Robyn Williams: Persuading the parents, how did you go about that?

Maureen Davis-Catterall: We put it to our parents. It's very difficult for our parents to be able to manage to get together $4,500. I believe that it's the trust that they have in myself as the principal that encouraged them to support me, and I thank them very much for that. And they all said yes, and off we went. It was wonderful.

Robyn Williams: Well, my blood gets chilled by the thoughts of bureaucracy and security and passports and all that stuff. I mean, walking around the block, let alone getting to Turkey.

Maureen Davis-Catterall: And how people can take more than 10 people away, it's phenomenal. Murray Henstock, the science teacher, and Jackie spent hundreds of hours on organisation, on paperwork. We met with the director on a number of occasions making sure every piece of paper was filled in correctly, the signatures were all in the right place. We had all of the things related to water activities, health cards, visas, the works. It was phenomenal. Hundreds and hundreds of hours goes into organising this adventure, and all credit to those two teachers for the work that they did, because if you don't have your paperwork right, once it goes to the director, then it goes to the executive director, and then it goes to the minister.

Robyn Williams: And the United Nations?

Maureen Davis-Catterall: No, but the minister was the last cab off the rank, and they all approved it. And so we are very fortunate. We had to watch the travel advice for over 12 months, it didn't change for Turkey, and we pushed it, and even the travel agents were very good because we were trying to meet deadlines and get the money together. We did a lot of fundraising and we worked really hard at making it happen.

Robyn Williams: Well, Jackie, when you get there, what is the program?

Jackie Slaviero: Istanbul, you get immersed in that whole culture. But because we are Australian and the strong links we have, we are very much embraced by the Turkish people. And so from there, Gallipoli. We stayed overnight there and took the students to the Anzac landing **site**. We went to Lone Pine, we made some film footage to use on Anzac Day, all of those things. And Ephesus, Troy, seeing the ancient ruins in real life. So when the subject selection comes up they can say, yes, I know a bit about ancient history, I might study that, or modern history is my thing, I've seen a lot of that.

Robyn Williams: But what about the camp?

Jackie Slaviero: Oh the Space Camp, well, that's a whole massive six days of astronaut training, seven simulators, observatories, planetariums, NASA astronauts visiting, many kinds of different scenarios, Mars rover **operations**. It's a massive program that's delivered in Turkish and English. So when we were there we were part of the Global Friendship **group**, so the students were split into groups with students from Israel, from the Golan Heights, from Greece, from Germany and America, so there were many different countries joined together. So two students from Wiley **Park** in every single **group** had to assimilate and network and become a part of that team, a global international team, so breaking down those barriers, and the tolerance and the self-esteem building and the leadership. It's a massive program.

Robyn Williams: Okay Murray, the poor science teacher who had to take these…how many did you take, Murray?

Murray Henstock: We ended up taking ten. Ten students from years eight all the way through to year 11. All girls, totally a girls school.

Robyn Williams: And where they puzzled about why they should know about space?

Murray Henstock: One of the things that we tried to do here is also encourage a bit of interest in science and space, and luckily we had a cross-section of girls who were already interested in science and girls who were just starting to develop their interest. So this was good.

Robyn Williams: And would you introduce me to the two students you have with you?

Murray Henstock: Today we have brought with us, we've got Iman Noufl who is one of our year 10 students, and Amina Harati-Farrow who is in year 11 and she is studying physics, so this was very, very relevant to what she's doing.

Robyn Williams: Year 10, okay, you went on the trip and what happened?

Iman Noufl: A lot happened! When we arrived at Space Camp actually it was more of you get to know who you're with, all the other countries, then we started a lot of simulators and we got into all of that, and I learnt a lot.

Robyn Williams: What about the interest in space itself and engineering? Did you have any to start?

Iman Noufl: Well, I like Formula One, so when you look at engineering, I kind of go into that when you talk about engineering…

Robyn Williams: You like Formula One car racing?

Iman Noufl: Yes, I do.

Robyn Williams: Why?

Iman Noufl: It's just so interesting, it's amazing, I don't know why, I just love it. But when it comes into engineering, yeah, it's fascinating how a rocket is just huge, and every tiny little thing has to be put in something huge, and if one thing goes wrong, everything fails.

Robyn Williams: Okay. And what did you get from the course, just being at the camp, wandering around, talking to the astronauts and so on?

Iman Noufl: It was actually really nice to know what you could do with astronomy and rocket science and everything, all the different paths you can take to go into that field. And yes, I have an open mind to what I might want to do right now. I could go into engineering for rockets or something like that.

Robyn Williams: Now, you're studying physics, are you, in year 11? How are you getting on with physics?

Amina Harati-Farrow: I love it, it's one of my favourite subjects.

Robyn Williams: How come?

Amina Harati-Farrow: It's fascinating and interesting to see the way the world works.

Robyn Williams: So you went away on this trip with some theoretical background, you knew about Newton and stuff like that.

Amina Harati-Farrow: Yes, that's right.

Robyn Williams: And so what did it mean to you, to have that same similar experience with the Space Camp?

Amina Harati-Farrow: It was helpful because before every simulator we were asked questions about Newton's laws and the way that the simulators would work.

Robyn Williams: So the simulators actually had you doing what the astronauts do?

Amina Harati-Farrow: Yes, they were copies.

Robyn Williams: They were copies, yes, I've seen them, they are really demanding. If you make a mistake, you crash!

Amina Harati-Farrow: Fortunately only a few were actually controlled by us, so most of them we just got strapped in and then a switch would be turned on and then they would simulate.

Robyn Williams: Did it strike you as complicated?

Amina Harati-Farrow: Yes. I was trying to look at how they worked. There was one that was really easy, it was just a chair attached to a suspension cable that would pull you up and take your weight.

Robyn Williams: And what about the rest of the Turkish surroundings with the ancient history? Where you into that as well?

Iman Noufl: I love history. For the ancient ruins they have marble, granite and **gold**, so much structuring put into the buildings, a very long time ago, all handmade, it was just so amazing to see.

Robyn Williams: Had you seen anything like it before?

Iman Noufl: No, I've never seen anything like it before, other than the pyramids. Knowing that they did it such a long time ago…wow! You walk in and it just changes your perspective on so many things.

Robyn Williams: By the way, both of you…may I ask where your families come from?

Iman Noufl: My background is Egyptian. My mum was born in Syria but background Egyptian for my dad.

Robyn Williams: And you?

Amina Harati-Farrow: My background is Moroccan, but both my mum and I were born in New Zealand, but my dad is from Morocco.

Robyn Williams: Isn't it a wonderfully complicated world?

Amina Harati-Farrow: Yes, it is.

Robyn Williams: So you saw all those things and you did your simulation and you learned about space. And what about coming back to your school in Sydney? Did the rest of the students think 'nah nah nah, you think you're special', or were there interested to know what you'd done and so on?

Amina Harati-Farrow: It was interesting because everyone would ask me what was my favourite part and I couldn't explain to them, because it was such an indescribable excursion I couldn't explain to them why I loved it so much.

Robyn Williams: And do you want Australia to make sure that science and even space industry is fostered?

Amina Harati-Farrow: Yes. If I do something in science, specifically physics, I was either going to travel to America or **China** because Australia doesn't have such a strong program.

Robyn Williams: And in year 10, what are your plans?

Iman Noufl: I have such a broad interest in so many different things. I haven't exactly picked what field I even want to go into. So I've got two years. Science-wise, I'd love to go into that field, but I don't know yet.

Robyn Williams: Murray, what lessons after a trip like this?

Murray Henstock: Well, it's quite interesting to see when they are there, and in the classroom we are talking about Newton's laws and physics and biology and chemistry, to actually have them design and build rockets and then talk about how the rockets work and air pressure and chemical reactions and then see them up on the simulators experiencing inertia, essentially a simulated zero-gravity environment, and then having to speak to an astronaut and actually meet face-to-face and listen to his stories about how he went through and got to where he was and the things he has experienced, trying to take that back now into the classroom has given ideas of what we can do to try and make our lessons more engaging, gives us some ideas on different experiments we can try and different ways of teaching some of the concepts. So that has

been really interesting for me, watching what they've done and going, okay, how can I replicate that in the classroom?

Robyn Williams: Principal, are you likely to do this again?

Maureen Davis-Catterall: Absolutely. Our plan is to have a two-year program, so every two years our school will immerse itself in an international program where we visit Turkey. After we've returned, the school is just abuzz with teachers and students. One of the science teachers walked up to me after the first day and said, 'Don't I know you've been to Space Camp! 'A' has just been in class and we're doing the **solar** system and she has been there, she's talked to astronauts. It just brought so much into the classroom, thank you very much.'

So yes, we are going to go ahead, we are already starting planning now because we've got a lot of funds to raise. But it's a program that will go across the school. We've already done a presentation to staff showing them where the curriculum links are in food, textiles, science, maths and the humanities. And in 2016 we will be off again and hopefully the Global Friendship Society will be able to afford us a couple of scholarships, so that it helps to reduce the cost. But the Space Camp exercise is just phenomenal.

Jackie Slaviero: And I've been made the Global Friendship ambassador for Australia, and I've been given 12 scholarships for next year, so I'**m** looking for another school who's up for the adventure, maybe to 24 students, so I'**m** looking at maybe a rural and remote school or a central school, somewhere out in the back of New South Wales who might be interested in joining in on this program.

Robyn Williams: What about the rest of Australia?

Jackie Slaviero: Well, if they'd like to contact me through you I'**m** sure we could work something out.

Robyn Williams: Well, there's invitation you can't refuse. Jackie Slaviero, the Space Camp ambassador. And before her the Wiley **Park** Girls School principal Maureen Davis. I also talked to Amina Harati-Farrow from year 11 and Iman Noufl in year 10, as well as Murray Henstock, science teacher. Details and pictures on The Science Show website, an inspiration for National Science Week.

And so on this Science Show on RN it's time for sleep. No, not you, only those birds who always seem to be so active. How do they keep awake for 19 days without harm, and is their sleep the same as ours? Here's sleepologist John Lesku at La Trobe University with Matt Smith…no, not that Matt Smith.

John Lesku: So when you are asleep, although your body is largely inactive and immobile, your brain is undergoing very different patterns of activity, unlike those that occur during wakefulness. And in other mammals there are sort of two basic types of sleep. One is called a slow wave sleep and the other is called rapid eye movement sleep, the state at which most vivid dreaming occurs. So my research is involved with identifying what is the purpose of these types of brain activity.

Matt Smith: So what's the difference between REM sleep and slow wave sleep?

John Lesku: You can distinguish between slow wave sleep and REM sleep by looking at changes in brain activity, measured by a device called the electroencephalogram, you know, what we think of as a polygraph or a lie detector test. And so when an animal is in slow wave sleep you see these very big, slow waves. And this pattern of brain activity stands in marked contrast to an awake animal which instead of having these big slow waves has the opposite; really small, really fast waves. So I'**m** trying to determine what is the purpose of these two basic types of sleep.

Matt Smith: Okay, but you're looking at birds specifically to determine this, aren't you, so why are you studying sleep patterns in birds?

John Lesku: All of the animals with which sleep has been studied using electrophysiology, only birds also engage in slow wave sleep and REM sleep. So sleeping brain activity has been studied in reptiles, amphibians, it's been looked at in some fish. But in all of these animals, although they actually sleep, their brain activity does not change in a manner that we would call slow wave sleep and REM sleep. So because only mammals and birds engage in these two basic types of sleep, it means that these two sleep states evolved independently in the lineage of mammals and the lineage of birds. So I study birds because I want to find out what is it about being a bird and what is it about being a mammal that causes their brain to need the same types of sleep?

Matt Smith: Is there a lot of difference then that you've noticed between bird sleep and mammal sleep?

John Lesku: Yes, there certainly is a lot of similarities between them. So if you stay up late at night or you are working late, you go to sleep several hours later than you would have on a normal night, then that when you ultimately sleep you sleep much more deeply or more intensely, and you can measure the depth as a

parameter of the electroencephalogram. So remember during slow wave sleep you see these big, slow waves, well, when you've been awake longer these slow waves are bigger when you ultimately go to sleep. The amplitude of these slow waves is really a marker of sleep depth or sleep intensity.

And despite independently evolving slow wave sleep and REM sleep, bird sleep is also regulated similarly. So if you keep a bird awake then they also sleep more deeply, as reflected in the EEG. In mammals, sleep is also regulated locally in the brain. So if you use a part of your brain more during wakefulness, so let's say you tap your finger for eight hours, well, the part of the brain that is responsible for processing that movement will sleep more deeply or more intensely locally, just that part of the brain will sleep more deeply relative to an unused finger.

And the same thing happens in birds. You can stimulate a part of the birdbrain selectively, say by visual processing, unilaterally make them watch television, so just one eye and one half of their equivalent to a visual cortex is watching television. And then you put electrodes over that brain region and you see that the brain region that was processing that visual input has a more intense or deeper sleep relative to the other half of the brain that was not receiving any visual input.

So in addition to being regulated globally as a function of prior time spent awake, sleep is also regulated locally as a function of brain use during prior wakefulness, and this also evolved independently in mammals and in birds.

Matt Smith: There are times when a bird would have to fly a lot, certainly the bird species when they are migrating. So do they need as much sleep as a mammal?

John Lesku: Across mammals, you know, we have good EEG-based sleep data for about 100 species, ranging from farm animals like cows and horses and some exotic things like Siberian musk deers and all sorts of weird things that people put electrodes on. And we find that even within mammals there is a huge range of variation in sleep times. So some animals, say horses, will only sleep for about three hours per 24-hour day, whereas you and I need eight, nine hours of sleep per 24-hour day.

Birds seem to have similar amounts of variation, but they can even go for seemingly extended periods of time without sleeping. Most recently we were in the high Arctic in Alaska looking at birds that travel seasonally from, say, South America, Argentina, Brazil, up to above the Arctic Circle to breed. And because they are breeding in the Arctic Circle during the summer, it's a very short, favourable time of abundant food, it's also a time of continuous light. So there has been thought for some decades that birds in this environment have probably stopped sleeping, but until recently no one has actually checked to see what the brain is doing during this time.

And so we fitted a particular bird called a pectoral sandpiper, it's a small shore bird, with these little gizmos for recording the electroencephalogram on wild free-living birds on the tundra. And remarkably we found that some of these birds could be essentially continuously awake for up to 19 days. The remarkable thing about these birds is that they didn't seem to suffer in terms of any impairments. So if you remain awake for, let's say, even one night, you'll probably notice lapses in motivation to do things, and yet these birds after 19 days do not seem to be particularly bothered in that the males that lost the most sleep were still able to convince female pectoral sandpipers, also living on the tundra, to mate with them. So they ultimately sired the highest number of offspring. So in this way sleep loss was adaptive in an evolutionary sense; males that lost sleep the most, that slept the least, ultimately sired the most young.

[Birdsong]

Robyn Williams: No, that's not a sandpiper, that's an Australian bird, but you were listening to Dr John Lesku at La Trobe University, with Matt Smith.

The bird you're hearing now is a regent bower bird, beloved of Germaine Greer. It's the species that convinced her to **buy** the **property** in Queensland.

Germaine Greer: Well, it wasn't so much that I bought it, it was that a bird **sold** it. A bird came out, as it were, the rep of the forest community and did this dance for me, which I still don't understand because I've never heard it mentioned that they could do this, and this black and **gold** bird came out and just did this mad shimmy dance. And every time I looked away from the bird it came back into my eye line as if saying, 'No, no, keep looking, keep looking.'

And finally it began to get dark, because I'd come back to the **property** right on dusk, and you know, the dusk in the subtropics just falls like an **iron** door. And I had to say to the bird, 'Birdy, I've got to go.' And the bird went back into the wild raspberries and I walked back down the track. And I saw the bloke who was living in the house on the **property** and said hi, and I thought, sorry mate, I'**m** going to **buy** your house. And it was **sold**. I put the cheque in the mail the very next morning and that was that.

Robyn Williams: Germaine Greer, author of White Beech with Michael Cathcart of Books and Arts Daily on RN last year. The book tells the tale of what happened next, and here to review it (brave man) is Peter Bernhardt, professor of botany at St Louis University in Missouri.

Peter Bernhardt: These days Australians deliberately **buy** land degraded by decades of **mining** and failed agriculture. Well-meaning people **purchase** these properties to restore native plant communities. Currently, the academic and journalist, Germaine Greer, is the most famous buyer and rehabilitator. Dr Greer bought a piece of south-eastern Queensland in 2001 and turned it into a charitable **company** less than 15 years later. In her book's epilogue, Dr Greer insists that land rehabilitation, based on private ownership, represents an investment far superior to money spent on eco-tourism holidays. I agree with her and respond with enthusiasm.

Dr Greer provides us with a well-organised and sharply focused book. Her first chapter discusses the origin and fate of the tropical, white beech tree of the title, but it's not a son of a beech! She explains that Australian timber merchants often named native trees after the finished European timbers they most resembled. White beech is really a titanic and woody member of the mint family, known as Gmelina leichhardtii. It was named after that long vanished explorer, Ludwig Leichhardt.

Dr Greer enjoys some initial success employing her own novel technique to encourage the mass sprouting of the finicky seeds of her white beeches. The three chapters that follow compare sites she considered buying. This includes a brief supernatural interlude in an abandoned **dairy** in Eden, New South Wales. All remaining chapters discuss the biological, anthropological and economic history of Queensland as it pertains directly to her former **property**, Cave Creek.

Throughout these chapters Dr Greer uses her historical research to support three overlapping arguments. First, virtually every agricultural and grazing scheme devised by white Australians, in her corner of Queensland, was and will always be unsuccessful. Second, most Australians can't recognise native species, especially those running country hotels in Queensland. Third, as Australians keep changing or misspelling the names of locations, people and organisms, they lose valuable information for future conservation policies.

In particular, she doesn't like the scientific names of her favourite trees and uses the phrase 'bloody botanists' as often as an older generation of Melbourne buskers used the phrase 'bloody poofters'. In fact, a passage in one chapter implies that both insults are interchangeable when one examines the bachelor lives of 19th-century botanists. Dr Greer insists that Aussie botanists named more species after each other compared to any other country in the world.

Maybe so, but I should report that the last North American species we studied in the Bernhardt-Meier lab included a rare milkweed named after a Dr Mead and a threatened peony named after Robert Brown, a scientist Dr Greer insists she admires. Dr Greer also complains that the famous Australian botanist, Barbara Briggs, never had a species named after her because Barbara's not a bloke. In fact, Darwinia briggsiae has carried her name since 1991.

On the other hand, Dr Greer loves to make noises like a botanist. The author uses a technical vocabulary throughout the book without apology and few definitions. The book has no illustrations or photographs or glossaries. Unless you have a degree in the plant sciences, be prepared to use search engines or keep lots of appropriate references on your night table.

How good is Dr Greer's use of technical terms? It's good but lacks precision. If birds eat the fruit of your Schefflera trees they are foraging on infructescences, not inflorescences, Dr Greer. Cryptocarya means more than 'hidden nut.' It means 'hidden walnut', probably after the myth of princess Carya in Greek mythology, Dr Greer. The 'eu' in Eucalyptus means good or proper, not pretty. Do I have to do everything?! Dr Greer explains she was taught to identify specimens using standard plant keys by her sister, Jane Burke. Jane is a botanist and appears throughout the book as the much needed, 'voice of reason'.

Let me also warn Australians that this book will not offer much instruction on how to regenerate tropical forests. Dr Greer and her work team killed invasive weeds, collected and sprouted seeds of remaining natives and planted them out. Unfortunately, there's no information on when they were planted, whether the soil required modification, which techniques made different species sprout, how close were young trees transplanted next to each other, whether they planted out canopy and sub canopy species at the same time, and so on.

Therefore, if you **buy** White Beech, remember that its subtitle, The Rainforest Years, is far more important than its title. The book offers wonderful anecdotes (guess what a carpet snake vomited after eating a koala?) but it is definitely not about Germaine Greer nurturing her forest friends. In no particular order, it concentrates on the history of Cave Creek's vegetation from the break up of Gondwana in the Cretaceous, through the arrival of fruit eating bats in the Tertiary.

Disastrous and genocidal decisions made by the first white colonists and regional governments, from the 19th century on to the present day, dominate this book. As Dr Greer quotes heavily, directly and frequently from so many historical sources, these overwhelmingly depressing passages resemble collaborative writings by Saint Rita and Keith Dunstan. Saint Rita, as you know, led a most unhappy but botanical life. She carried a thorn in her forehead that produced a wound that never healed. Dr Greer insists she's thorn free but bleeds often from the spines of lawyer vines (Calamus muelleri). Don't we all?

Robyn Williams: Well, maybe. Peter Bernhardt is professor of botany at St Louis, and his book Darwin's Orchids: Then and Now is published by Chicago, it was in collaboration with Dr Retha Edens-Meier, also of St Louis University. And he wishes to inform Dr Greer that his 1981 PhD from Melbourne University is in botany, not in English and French literature. So there. He was reviewing White Beech by Germaine Greer.

And this is The Science Show on RN.

And now we combine some of those last thoughts; lawyers, France and Melbourne. Though Monash this time. Meet Stephanie Gras, whose field is X-ray crystallography, and whose hero is one Lawrence Bragg.

I was telling you that a roomful of lawyers had never heard of Lawrence Bragg, do you find that surprising?

Stephanie Gras: It's a shame. It's not surprising, I don't think so, unfortunately, but it is a shame. He was one of our great scientists for crystallography, but most importantly he is Australian. He was born in Adelaide and went to the University in Adelaide, and with his dad they were working on X-ray diffraction and they won the Nobel Prize in 1915.

Robyn Williams: In other words the anniversary is coming up next year.

Stephanie Gras: Yes, next year, and this year is the anniversary of the discovery of the X-ray that could be used through crystals and that was by Laue in the same time.

Robyn Williams: How many people in France know about Bragg?

Stephanie Gras: Well, probably the crystallography community, which is quite big in France, but yes, I don't think it is known by the public unfortunately.

Robyn Williams: Quel dommage!

Stephanie Gras: Très dommage!

Robyn Williams: And you've come here especially to continue this work on X-ray crystallography. What aspect?

Stephanie Gras: Medical crystallography. So I'm working on immunology and trying to understand a bit better the immune system, and some of the greatest scientists in immunology are actually based in Melbourne, so…

Robyn Williams: Like Peter Doherty.

Stephanie Gras: Like Peter Doherty and Jamie Rossjohn who I work for. And so during my PhD in France I actually read some articles and they were a very high level of science, and I thought why not sending them an email and say that I actually came to Australia for my honeymoon with my husband and I was looking for a job after my PhD. And three months later, here we are. I've been living in Australia since a bit more than seven years now.

Robyn Williams: And it wasn't disappointing?

Stephanie Gras: Not at all! No, the first time we came in Australia, after a week we just fall in love with the country, it's just so beautiful. And in terms of work and of science it's so exciting, so it's a fantastic place to live in.

Robyn Williams: What work specifically are you doing?

Stephanie Gras: I look at how our immune system is actually able to see viruses and very, very small particles of the viruses, and how upon presentation of those small particles our immune system is able to detect them and to kill them. My work is actually looking at the atomic level, so it's very, very tiny scales, and looking at how those molecules interact together to produce a good immune response.

Robyn Williams: When you think you can have 100,000 viruses in a small drop of water, and when you think of all the different kinds of virus, isn't our body clever to be able to spot them so quickly and deal with them usually.

Stephanie Gras: Yes, most of the time our body is doing a great job at actually seeing them and recognising what is a virus and what is actually a healthy cell and making the difference between them. But viruses are trying to be a bit more clever and trying to escape unfortunately, because that's kind of a little play of mouse and cat, and it's which one is going to actually survive and go on with its life. So it's a real challenge that our immune system is actually facing.

Robyn Williams: How do you get down to the atomic level to look at this?

Stephanie Gras: So we are actually making crystals, like for example if you look on your dinner table you would have salt, those tiny shiny little particles are actually crystals of salt. So I do the same thing but with protein from the immune system, so they are becoming those tiny shiny crystals of protein from the immune system. From Monash, we are very fortunate that in Australia we have the Australian Synchrotron, so I just have to cross the road from our laboratory. The Synchrotron is pretty much like a giant microscope. So with the regular microscope you will see something big like a cell, and what I'm looking at, it is composing the cells, so it's really, really tiny, tiny, and we need something very powerful like a synchrotron to do this.

Robyn Williams: With its X-rays.

Stephanie Gras: Yes.

Robyn Williams: So you've got these pictures, and…well, what do you find? Do you find that there are so many different kinds of viruses, all different shapes?

Stephanie Gras: Yes, they are pretty much different shapes. So what we're looking at is actually tiny particles of the virus because when the viruses enter inside our cells it got degredated into very small fragments, and those fragments are presented to all our cells and actually presented to what we call T-cells, so the lymphocyte, and those lymphocytes, they are actually the ones that will recognise the virus, and will say, well, this cell has been infected and I need to destroy it. So what I look at is the complex between the receptor of those lymphocytes, and peptide antigen from the viruses and the protein that is about to present those peptides.

So what we are looking at, for example, in the case of influenza or HIV is actually looking when the virus starts mutating, how sometimes those mutations make that our T-cell won't see those new variants anymore, so they will escape our immune system. And so we try to understand how they escape, not why they escape because that's the primary role of the virus, trying to survive, but if we can actually challenge our immune system a bit differently to make them respond to the variant.

Robyn Williams: So in other words, if you can imagine this invader coming in and the white blood cell, the T-cell comes and takes a sniff and gets an idea of the shape and reports back to headquarters saying, yes, we've got one of those, we know about those, bring out the troops. And of course then the virus mutates, as you said, and changes, and so you've got to work out perhaps what that change might look like.

Stephanie Gras: Yes. So if we can predict those changes, because the T-cells, they need some time to actually be very efficient and start dividing so there is more of them, so you've got this bigger army of cells ready to attack those infected cells. And so to try to optimise our chance of getting those T-cells in place and very early on during infection, we need to understand how they actually interact and how sometimes they fail to interact with those variants of peptides.

Robyn Williams: Well, you mentioned HIV, and of course after the great big 2014 HIV AIDS conference, people bemoaned the fact that there was still no vaccine, and with Ebola, which we are worried about at the moment, still no vaccine. What do you have to do to crack it?

Stephanie Gras: Well, the work on HIV, even though a lot of people have been involved in the research on HIV, it has been only 30 years of research, and in the research field that's not as many years as what we have on other viruses. So even if the field is very active, there is still a lot of things we still don't understand about HIV. One thing which is quite amazing is the rapid mutation of this virus. HIV can change 100,000 times faster than the flu, and we need a new vaccine for the flu every single year.

Robyn Williams: 100 times faster?

Stephanie Gras: 100,000 times faster.

Robyn Williams: 100,000 times faster!

Stephanie Gras: In a day the number of new viruses HIV is able to produce in the human body is absolutely staggering, and that's the real challenge because if we are to make vaccines, between the moment someone gets infected and someone gets sick, the virus has already evolved. It evolves very, very rapidly. It's a virus that has an enzyme that makes a lot of mistakes while replicating, and that makes a lot of new

viruses. So it's a real challenge to actually try to get a vaccine. There's a lot of work done on a neutralising antibodies at the moment that is very promising, and the community and scientific community is so actively working on it. But it's a very, very challenging virus.

Robyn Williams: Of course one of the nasty things that some of these viruses do is invade our DNA so that our DNA actually makes them the viruses themselves.

Stephanie Gras: Yes, so the virus will actually get into our cells and use all our system to actually replicate itself, create new viruses and go infect other cells.

Robyn Williams: It's like a science fiction horror story, isn't it.

Stephanie Gras: It is a bit, unfortunately, but the good side is that viruses are smart but I believe we are smarter and we should definitely one day be able to crack it.

Robyn Williams: Well, I'**m** terribly pleased you came from France, thank you.

Stephanie Gras: Thank you very much.

Robyn Williams: 100,000 times faster, that HIV mutation, faster than the flu virus, and that's bad enough, as you can hear from my voice. Stephanie Gras is an ARC Future Fellow at Monash University.

And across the city at La Trobe University our PhD this week is also using tiny creatures to work out why you and I get sick, or deaf. Sam Manna is using slime moulds to investigate your mitochondria, those power packs that keep us alive.

Sam Manna: My research involves investigating the mitochondrial genetics of the soil dwelling amoeba Dictyostelium discoideum. Like humans, these amoebae contain specialised cellular compartments called mitochondria, which produce the **energy** we need to survive by breaking down sugars. Mitochondria have their own DNA, which is inherited maternally. This DNA encodes the information required to make the proteins that break down sugar and produce this **energy**. The process by which proteins are made from DNA is referred to as gene expression. Mitochondrial gene expression requires strict control and regulation, as even minor defects in this process can **lead** to dysfunction of mitochondria and can cause diseases such as Parkinson's, Leigh's syndrome, and even specific forms of inherited blindness.

I work with Dictyostelium as it is a good model organism to study mitochondrial gene expression. Compared to human cells, Dictyostelium is easy to grow and genetically manipulate, but the key factor about working with this model is that the molecular biology and the mitochondria of the Dictyostelium cell is very similar to that of humans, therefore the information we obtain by studying mitochondrial gene expression can be applied to human mitochondrial biology and disease.

My PhD research focuses on characterising proteins involved in regulating the different steps in mitochondrial gene expression. The first protein I identified was named mitochondrial transcription factor **B**, which binds to mitochondrial DNA and activates the expression of mitochondrial genes. It was also found to have a role in increasing the production of mitochondrial proteins, and as a consequence, **energy** production.

In humans, mutations in mitochondrial DNA can **lead** to hyperactivity of the mitochondrial transcription factor **B** protein, and can cause maternally inherited deafness. This deafness is often induced after a course of antibiotics as the hyperactivity of this protein increases the sensitivity of cells in the ear to these antibiotics, and I have been able to reproduce this in my studies with a Dictyostelium version of this protein.

An important step in producing proteins within mitochondria is RNA production. Expression of the mitochondrial DNA first leads to the production of the RNA molecules that act as messengers. These RNA molecules are subjected to a number of modifications before they are used to make mitochondrial protein. One family of proteins involved in mitochondrial RNA modification are PPR proteins. In humans these proteins have been implicated in a rare form of Leigh syndrome called French-Canadian Leigh syndrome. This neurodegenerative disorder affects the central nervous system due to a loss of motor skills, and a disturbance in mitochondrial gene expression, resulting in mitochondrial dysfunction and low-level **energy** production. People with this condition normally do not survive beyond two years of age.

Disturbing PPR genes inDictyostelium resulted in slower growth, which is characteristic of lower **energy** production, and mitochondrial dysfunction, similar to that observed in individuals with French-Canadian Leigh syndrome. During my analysis of PPR genes in Dictyostelium, I also identified a novel **group** of PPR proteins. These proteins are not only present in Dictyostelium but also in algae and disease-causing amoebae like Entamoeba, which can cause amoebic dysentery.

Interestingly, PPR TGM genes did not originally belong to these organisms. Instead, a primitive version of these genes was provided to them by an ancient species of chlamydia. By studying how mitochondrial gene expression is regulated in a model organism like Dictyostelium, we can apply this knowledge to humans and begin to understand the molecular biology of diseases, like maternally inherited deafness and Leigh syndrome. This can therefore **lead** to and allow us to test potential treatments for mitochondrial diseases.

Robyn Williams: Sam, fascinating work. You mentioned deafness before. Is that common?

Sam Manna: It would depend on if they are actually exposed to antibiotics or not, so whether or not they have the mutation doesn't always determine whether or not they will actually get the deafness. Some patients will have the mutation and won't go deaf unless they get treated with antibiotics. Others, on the other hand, can become deaf even without exposure to antibiotics. So it's more complicated than just the one mutation.

Robyn Williams: Sure, but in a population like Australia's, how many per year would get that kind of deafness?

Sam Manna: It's somewhat rare, so it would probably be approximately 1 in 5,000, maybe more.

Robyn Williams: I see. Well, good luck with your work, it's fascinating stuff.

Sam Manna: Thank you.

Robyn Williams: Sam Manna, and yes, he is often called 'Manna from heaven', but I didn't check out by who.

And beyond the complexities of those proteins, isn't it fascinating how he can use slime moulds, those tiny amoebae in the soil, to study how your cells work or may go wrong. And that influence of antibiotics is crucial.

Sam mentioned algae just now, and so here is Stephen Mayfield who talked here about algae and **energy** supplies earlier this year. But this is now work on algal proteins to help make vaccines and, would you believe, against malaria.

What's this I hear about algae and vaccines?

Stephen Mayfield: Well, algae are eukaryotic cells, and so like every eukaryotic cell, what that means is they spent a fair amount of time making proteins. Some of those proteins go into the photosynthetic complexes, that's the things that harvest sunlight, and some of them go into the CO2 fixation process, an enzyme called RuBisCO. But you can also direct those proteins to be pretty much anything we want nowadays, so we can rewrite the software of those cells and we can put in programming that says, hey, instead of making an algae photosynthetic protein, why don't you make a malaria surface protein? And we did that last summer. And the algae cells happily made malaria surface proteins and we extracted those proteins, injected them into mice and we could show that we got a very nice antigenic response in the mouse that gave them resistance for malaria. So that's what a vaccine does.

Robyn Williams: Can it be used medically?

Stephen Mayfield: Absolutely can be used medically, and in fact there are companies now that are producing vaccines in plants, and algae is simply an aquatic plant, so those vaccines have already gone through clinical trials, came through with flying colours. We are now producing several different vaccines in algae. We still had to take those through clinical trials, meaning that we have to show they are effective, that they are safe. But so far all the evidence is that they are going to work really well. So what's the big advantage of algae? Cost and scale.

Robyn Williams: Well, of course it's been one of those great challenges in science over the last century, trying to find a vaccine for malaria, which is killing, what, a **million** people a year and affecting their lives in a drastic way, on a far bigger scale than that.

Stephen Mayfield: Yes, that's right, malaria vaccine is sort of the Holy Grail for vaccines. Unfortunately even a vaccine produced in algae, because you have to purify the protein and inject it, is still pretty expensive and you need a medical infrastructure. So even though some of the vaccines we have now are promising, it's very difficult to imagine those are going to scale to be able to inject 2 **billion** people, especially 2 **billion** people who don't have a lot of money themselves for the vaccine.

So what we've been working on now is to make an orally available version of that. In other words, could we get a vaccine antigen produced in an algae where you never purify the antigen, you simply feed the algae

to an individual, that protein transmits across the gut, forms an immune response and you get resistance. It's worked on pathogenic bacteria antigens using algae to express that vaccine, and we are working now to see if we can get it to go with malaria. Promising, but early days.

Robyn Williams: So would a drug **company** take that on, given the fact that most of the customers would be poor people?

Stephen Mayfield: Well, we think that's why you have to go to something orally available where you are not purifying it. Our calculations are that if you don't have to purify the protein and you are just feeding the algae, then you can get a vaccine dose for about 0.6 cents, so less than a penny per dose. And at less than a penny per dose you can think about giving it away to 2 **billion** people.

Robyn Williams: Professor Steven Mayfield is director of the California Centre for Algae Technology in the University of California, San Diego. And if he's right and it works; eureka!

Next week The Science Show turns 39, and we shall indulge ourselves by hearing the man whose book topped the 40-year combined bestseller list of the Sunday Times of London. Can you guess? And from Richard St Barbe Baker, the Men of the Trees.

We shall also look forward to the 30th birthday of Ockham's Razor, with a stunning story about Scott of the Antarctic, and Marie Stopes of sexual health fame.

The Science Show is produced by David Fisher and Timothy Nicastri. I'**m** Robyn Williams. And this is Mic Conway in outer space:

CD Title: Diagonally Parked in a Parallel Universe

Performers: Mic Conway’s National Junk Band

Track Title: Diagonally Parked in a Parallel Universe

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