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#384: Exploring the impact of city lights on birds, and building better detergents

VOICEOVER

Welcome to Up Close, the research, opinion and analysis podcast from the University of Melbourne, Australia.

ANDI HORVATH

Hi, I'm Dr Andi Horvath, and today we bring you up close to PhD level research. We're often grateful to the urban planners of the past who left spaces for parklands and botanical gardens in our cities where we can have picnics, stretch out on the grass and even feed the birds. But hang on. Should the birds be equally grateful for our cities, and what about the downside of sitting on all those beautiful lawns, those nasty grass stains on our clothes?

In this, our annual PhD episode of Up Close, we speak to two young researchers on diverse topics that come together in this imagined scenario. Later in the program we'll hear from doctoral candidate Mitchell Nothling who's exploring how enzymes found in nature, and in particular our digestive systems, could be a clue to designing more effective detergents to help us get out those grass stains.

But first, we speak to Annie Aulsebrook, also a PhD candidate, who's looking at how birds are affected by the bright artificial lighting we build in our cities. Annie is investigating the impact of light emissions on swans and pigeons, and in particular how it might change their behaviour and melatonin levels. We know light pollution affects human behaviour too, but what is the effect on birds and how might this research help to inform future urban planning? Annie Aulsebrook works with bio-scientists at the University of Melbourne and at Latrobe University. Annie, welcome to Up Close.

ANNIE AULSEBROOK

Thank you.

ANDI HORVATH

Now, the reason we can't see stars in our city is due to light pollution, much to the frustration of amateur astronomers trying to see the stars, but there are measurable effects from light pollution on people and animals. Can you tell us more about that?

ANNIE AULSEBROOK

Yeah, lots of research so far on the impacts of light pollution on wildlife has focused on the timing of behaviour. In Europe they've found that birds in light-polluted areas start singing earlier. They might be active for longer during the day and be more active at night. There's also some species that will avoid light at night, so some bats will completely avoid brightly-lit areas. Others actually thrive on brightly-lit areas, so the fast-flying bats will pick up on insects that are drawn to lights. There seem to be a lot of diverse impacts on wildlife.

In humans, a lot of the focus has been on health, which makes sense, and we often tend to focus on brighter lights when we're talking about humans because they're the lights we're exposed to indoors. So for example, when you look at an iPad before bed, some research has found that that can affect your sleep and how you're feeling the next morning.

ANDI HORVATH

Especially that blue light.

ANNIE AULSEBROOK

Yeah, that's right. Blue light suppresses the hormone melatonin, which is important for our circadian rhythms which are those internal daily rhythms in behaviour and our physiology such as sleep.

ANDI HORVATH

Now you've decided to focus on urban lighting and its effect on birds. Now, why birds, and what has the research taught us about this so far?

ANNIE AULSEBROOK

Birds are interesting because they're in some ways more similar to us than the lab rodent models that we tend to use. Mice and rats tend to be nocturnal, while birds tend to be diurnal like us, so they're active during the day and they sleep at night. So that's part of the interest in birds.

Research, so far like I said, has focused often on behaviour. There's been evidence that bright light at night, or even quite dim light at night similar to a full moon, can actually suppress melatonin in some birds, which could have really important implications for learning and health and development if that is having impacts on sleep as well, and we know that melatonin's also important for the immune system as well.

ANDI HORVATH

Annie, the swans have been in our parklands for a long time, so what's the impetus to explore this question, and why the swans in particular as opposed to other bird species?

ANNIE AULSEBROOK

For a few reasons. One, a lot of the focus has been on songbirds, which have very strict daily rhythms, and swans are a bit more flexible. So it would be interesting to see how they affected. Swans are also very convenient to study. They're very big, easy to see, quite easy to catch down at Albert Park because there's people down there all the time and they're very used to people. This population at Albert Park lake has been studied for the last 10 years as well, so all the Swans can be individually identified. They all have tags so we can see who they are from a distance, and because of their size it makes it easy for them to carry small data loggers that we can use to measure their activity and also their sleep.

ANDI HORVATH

Now, Albert Park lake is a large body of water in Melbourne, Australia, and just to remind our international listeners, our swans are black. Tell us about the difference between black swans and white swans.

ANNIE AULSEBROOK

They're quite closely related. The black swans are black all over except for the adults. Under their wing, they have a patch of white.

ANDI HORVATH

Essentially they're the same species.

ANNIE AULSEBROOK

No, not the same species, but closely related.

ANDI HORVATH

Now you said you've fitted the swans with trackers. Is this kind of like putting a Fitbit on a swan?

ANNIE AULSEBROOK

Exactly. So we put accelerometers on the swans, which essentially are Fitbits, and so they measure movements in three dimensions. So we can use that to figure out what the swan's doing and when it's active.

ANDI HORVATH

How do you take a blood sample from a swan? How much of a blood sample do you need?

ANNIE AULSEBROOK

Not a whole lot. So we use the blood samples for a few reasons. We use them for determining the parents of each swan, and we use them for sexing the swan through genetics, because it can be quite difficult to tell males from females, and I'm using them to measure melatonin. It's basically about 200 microliters I use.

ANDI HORVATH

So essentially we're just talking a drop of blood.

ANNIE AULSEBROOK

Yeah.

ANDI HORVATH

So tell us more about swan physiology and behaviour. Do swans have the same deep sleep patterns that we do? Do they have REM sleep and non-REM sleep?

ANNIE AULSEBROOK

Yes. So birds have rapid eye movement sleep and non-rapid eye movement sleep. They're quite different to us in the sense that they can move between these cycles quite quickly. A human sleep cycle can be about 90 minutes all up, but in a bird they can go into rapid eye movement sleep for just a matter of seconds, maybe five, 10 seconds. In birds, the brain activity during rapid eye movement sleep looks a lot like wakefulness, and not all birds have corresponding changes in muscle tone that humans have, so it can be quite difficult to identify.

ANDI HORVATH

Is there a difference between the male and female in terms of their behaviour in nesting?

ANNIE AULSEBROOK

Yes. Males and females, they take it in turns incubating the eggs on the nest, and past research has suggested that males tend to incubate the eggs during the day while the females tend to incubate the eggs at night. So that's one thing that I'm interested in for my research, because essentially the male, presumably, has to become almost nocturnal during that period, because if he wants to forage and find food he has to do it when he's not on the nest.

ANDI HORVATH

So Annie, what are the likely impacts on birds from excessive city lights?

ANNIE AULSEBROOK

So if streetlights are suppressing production of melatonin in birds, that could be having impacts on immune functions, on health. Melatonin is also involved in processes related to aging. There could be implications there. In terms of sleep, as well, we know that sleep is really important for learning, for development and for daily performance and, particularly for a wild animal, if it's less vigilant because it's tired then maybe it might be more vulnerable to predation or it might not be as good at protecting its eggs, or it might be more aggressive. There's some slight evidence that sleep is related to those types of behaviours.

There's also the possibility that birds just avoid light at night. My research so far, I don't think that's the case for the swans, but for other species perhaps, if they're avoiding light at night they might not be getting those physiological impacts but it might be having other impacts. So it might mean that they're less efficient at foraging because they have to avoid particular areas, and that might be more relevant to nocturnal animals like owls rather than diurnal birds.

Another possibility too is that diurnal birds being more active at night could start encroaching on the niche or the space that is used by other species, creating competition where it didn't exist before. So there's a lot of possibilities.

ANDI HORVATH

So without trying to pre-empt your findings, what would it mean if streetlights were indeed found to have a negative impact on bird life? What would happen then?

ANNIE AULSEBROOK

I think we need to start thinking about minimising our light to where it's actually needed. Because lighting has got so cheap now - it's also getting more energy-efficient - lights are often just put up everywhere with the assumption that people want them. That's not necessarily true, and it can have these negative effects. So I think we need to start thinking about minimising our lights. There's already a lot of talk about making sure lights are shielded, so that they're only actually lighting what we want them to light. Also about the spectrum that we use in our lighting, so reducing that blue peak in our LED lights.

ANDI HORVATH

Oh, getting those warmer LEDs, perhaps?

ANNIE AULSEBROOK

Yeah, warmer LEDs or using filters, which kind of like cellophane, they can change the colour of the light.

ANDI HORVATH

So basically rethink urban lighting.

ANNIE AULSEBROOK

Yeah. The common term that's being used is smart lighting, so making our lighting smarter.

ANDI HORVATH

Tell me about urban ecology in general. How important is it to have animals that are happy in our cities?

ANNIE AULSEBROOK

I think there's two main reasons. One is that urbanisation is increasing and more and more people are living in cities. Cities are growing, so they're forming a huge part of our environment. So we can't just conserve or look after the wildlife that's outside of our cities.

Another reason is that we live in the cities, and if we are surrounded by wildlife that we care about and we get those positive interactions then people are more likely to care. So if we can't care about what's within our cities, then how are we going to care about what's outside them?

ANDI HORVATH

Annie Aulsebrook, thank you for talking to Up Close.

ANNIE AULSEBROOK

No worries, it was a pleasure.

ANDI HORVATH

You're listening to Up Close. I'm Andi Horvath, and I'm chatting to two young doctoral candidates - Annie Aulsebrook and Mitchell Nothling - about their research and its possible impact for the rest of us. Our trip to the park to feed the swans will never be the same again.

Now, today's enzyme-based detergents, including the powders you pour into your washing machine, only work at specific temperatures, and that has an impact on when and where they can be used. But can we improve on nature's design of enzyme action, and in what situations would it be useful? What's all this got to do with our own digestive systems? Our next guest, chemical engineer Mitchell Nothling, is a PhD student at the Melbourne School of Engineering, and he joins us

now to discuss his research in this area. Welcome aboard, Mitchell.

MITCHELL NOTHLING

Thanks very much, Andi.

ANDI HORVATH

Mitchell, let's start with what is an enzyme, what do they do?

MITCHELL NOTHLING

So enzymes, without exaggeration, are probably the most important class of molecules that underpin life. They're nature's catalysts, so they speed up the reactions that make life possible. They're incredibly widespread. They occur from the energy conversion in plants to your digestive system, as you mentioned, to the immune response and almost every major physiological function.

ANDI HORVATH

These are the same things that are involved in brewing, and things like that?

MITCHELL NOTHLING

That's exactly right, yeah. So they've been used indirectly by humans in industrial applications since pre-history.

ANDI HORVATH

So don't we already have detergents with enzyme action? I'm sure I read that on the pack. Why is this study needed?

MITCHELL NOTHLING

Yes we do. Enzymes are added to detergents, and that's probably the largest application. The issue, as you alluded to, is that enzymes have a very narrow operating range. So they evolved under physiological conditions, so they work well at the body temperature, in body pH and salt concentrations, but when we move outside of that range we find that the effectiveness of the enzyme is degraded.

So for a laundry application, if we're running at cold or hot temperatures then we find that the effectiveness of the enzyme additive is not as good as it could be.

ANDI HORVATH

Right. Let's talk a little bit more about the biological enzymes that need particular conditions to perform. They're a bit like demanding rock-stars, really. So they need a particular temperature, but are they a one-use thing? Do they fall apart under different conditions of alkalinity? What are some of the other things involved with enzymes?

MITCHELL NOTHLING

That's the nice thing about nature's catalysts, is that they evolved to be very specific. So they react to one specific substrate, which is the material that they break down in or bind together. Enzymes do a number of functions. So the enzymes in the digestive system work on the things that we typically eat. They work at the temperature that the body works, and under the conditions of the stomach.

ANDI HORVATH

Mitchell, tell us about the business end of enzymes. What exactly is involved? Are they like little Pac-men?

MITCHELL NOTHLING

Yeah, that's exactly right. So you can think about them sort of like a very small mouth, on a molecular scale, with a very ordered set of teeth, but these teeth are made up of amino acids. So this is the same material that makes up every protein in your body, and in fact enzymes are, themselves, proteins - catalytic proteins.

ANDI HORVATH

Proteins that split proteins? Is that right?

MITCHELL NOTHLING

Yes, some are. So the enzymes that split proteins are called the proteases, and they all utilise a similar mechanism to do that degrading. So these are the enzymes that are found in your stomach, created by your pancreas, and they degrade the triglycerides - fats and oils that are part of your diet. They make more soluble

products so that your body can more easily get at the energy that's held within.

ANDI HORVATH

Now this brings me to my next question. Can we improve on nature's designs, because I think that's what you're trying to do, yeah?

MITCHELL NOTHLING

I absolutely am, yes. The issue with enzymes is their low stability, so that really narrows the operating range that we have for industrial enzymes, in particular in detergents. So if we could reduce the temperature that we could run our washing machine at, for example, then that would be a massive saving in energy, that we don't have to heat the water up, and would have particular impact in parts of the world - in countries that don't have that ready access to hot water.
So we can do this by trying to limit the use of the protein natural structure. So with natural enzymes, it's the protein t
hat brings all of these amino acid teeth into proximity to afford the catalysis that we're interested in, but this bringing into proximity is very susceptible to small environmental changes. So if we could remove the need to have the natural protein then we would have a material that is more resilient.

ANDI HORVATH

Now I have to ask, a lot of detergents can be disastrous for the environment. So tell us about why this work matters.

MITCHELL NOTHLING

A lot of detergents are an issue for the environment because of the additives that they need to have, so the various phosphates and surfactant molecules cause issues downstream in the environment. The enzyme additive isn't so much of an issue. Because it is a natural material, it's very widespread in the environment, so natural enzymes aren't an issue.

The material that we're trying to develop to replace enzymes or to substitute for enzymes, we're not at the stage yet that we can say whether these things will be an environmental issue, but the idea that we want to work towards is that they're very reusable. So we should not be making any undue waste out of these materials, and the idea is that, for example, we could coat a washing machine with an enzyme-mimicking coating, and then remove the need for a detergent altogether.

ANDI HORVATH

Alright, give us some more context about how this will help society, or even industry.

MITCHELL NOTHLING

So the detergent application is just a small window. That's where our funding has come from, so that's where the focus of the research lies. But this approach that we're using, of mimicking the functional core of enzymes, is very applicable to other types of enzymes, not just the proteases. So we could foresee an application in biodiesel production if we can get these materials to perform the types of reactions that are required in biodiesel preparation.

We could also see antibacterial applications. So these sorts of materials mimic the antibacterial properties of natural enzymes. So if we could reproduce this onto a coating for a dental implant, for example, then we could begin to move towards antibacterial surfaces.

ANDI HORVATH

Right. So you're really working on the chomping teeth of the Pac-Man, but putting it on a different handle?

MITCHELL NOTHLING

That's exactly right. When you get down to the core of enzymes it's actually a very small, simple area that does the actual function that we're interested in. The key that the enzyme uses is bringing these into perfect alignment like a lock to accept the key of the substrate, so if we can take that small lock and mount it onto a number of different surfaces or surfactants then we can target it more appropriately as an application.

ANDI HORVATH

Now, a lot of research involves collaborations, and of course funding bodies. Tell us a little bit about that.

MITCHELL NOTHLING

So, we've received funding from Unilever from the earliest stages of this work. They're looking more at the potential of this application in detergents, so they're most interested in being able to reduce the washing temperature. So if we can move from

having to heat water to 10 degrees or 20 degrees Celsius then the situations that we can use these sorts of materials widens.

ANDI HORVATH

What have you found surprising during your PhD studies so far?

MITCHELL NOTHLING

So, a surprising thing for me was we've actually developed an assay technique. So this is a test that we use to determine how well these materials work, and I had spent a significant amount of time and effort to establish whether our new materials can break things down like we hope they would, and an interesting result for me was when we compared these to the natural enzyme chymotrypsin, which is a digestive protease. It occurs in mammals and is developed by the pancreas.

The interesting result for me was that our materials outperformed this natural enzyme, chymotrypsin, under the assay conditions that we had. So this is room temperature, with organic solvents added. So if our materials can outperform a natural enzyme under these tightly controlled environments then maybe there's wider application for them.

ANDI HORVATH

So what are the challenges of doing this kind of research?

MITCHELL NOTHLING

So the challenge is that nature has had billions of years to evolve these perfect catalysts, so enzymes are incredibly effective at the jobs that they were evolved to do. The enzymes in your stomach degrade food a billion times faster than would be possible without their presence. So having this as a goal to try to replicate has been a significant challenge.

The first step was to identify how we wanted to replicate the enzyme's function, and we've ended up with quite a simple model now, and quite a straightforward synthesis to make these new materials. The issue has been trying to differentiate from enzymes. I don't think that we'll ever approach the function of enzymes under physiological conditions and under the very specific substrates that they react on, but I think that the application for this technology is outside of that range, so lower or higher temperatures, pH and salt concentrations.

ANDI HORVATH

Mitchell Nothling, thank you so much for sharing your research with us.

MITCHELL NOTHLING

Thanks very much, Andi.

ANDI HORVATH

We've been speaking with two PhD scholars, Mitchell Nothling from the Melbourne School of Engineering, and Annie Aulsebrook who's doing her research at the School of Biosciences, University of Melbourne.

Up Close wishes our PhD students the best of luck with completing their research. You'll find a full transcript and more info on this and all our episodes on the Up Close website. Up Close is a production of the University of Melbourne, Australia. This episode was recorded on the 29th of November 2016. Producer is Eric van Bemmel, audio engineering by Gavin Nebauer, and I'm Dr Andi Horvath. Cheers.

VOICEOVER

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