Ruth Bowness talks with our new Newsletter Editor, Thomas Woolley.

Thomas is a Senior Lecturer in the School of Mathematics at Cardiff University in Wales. Thomas is also a keen participant in mathematical outreach workshops and has given a variety of popular maths lectures nationally and internationally.

1. Tell us a bit about your research area

   Theoretically, I work on developmental biology, namely how does complexity arise from simplicity? More realistically, I'm a dilettante who's happy to work on any project that people are interested in. I'm just interested in learning and applying the right maths to best answer applied problems. As such I've worked with biologists, historians, social scientists, IVF technicians and beyond. I love the diversity.

2. How did you arrive in your current position?

   By bus…

   More usefully, I did a straight MMATH degree at Oxford University, but it was in my third year, where I did a course in mathematical biology, that opened my eyes to what maths could do. The whole course was great, but the application of Turing patterns to understand pigmentation was absolutely beautiful.

   Ever since then I knew I wanted to understand them better and I got a doctorate in working on the stochastic Turing patterns. Since then I've just been happy to work on a diverse number of problems and with international collaborators.

   I'll be honest, getting a permanent position was slow and difficult, but, after a huge number of applications, Cardiff took a chance on a new area of research, as I was their first mathematical biologist. Since then they've hired a few more and our collaborations have grown beautifully.

3. Describe some exciting research you are currently working on

   I'm working on a number of theoretical pieces at the moment because Covid-19 has shrunk my experimental collaborator network, so although I'm interested in the maths, it is a bit dry and technical.

My most exciting piece of applied research that I did recently was modelling the expulsion of precancerous cells in the pancreas. The reason it was exciting was because the base model was easy to produce. However, the results that appeared were unexpected. Critically, not only were we able to fit biological data to the model suggesting that we understood the biological mechanism, but I was also able to highlight a stochastic effect that was novel (to me, at least). Namely, if we consider an invading population of a thin grid, then as we make the grid wider the population invades faster. This is not a result that would be seen in the deterministic model.

For me, this is the best kind of math bio. Not only are you learning something new biologically, but it motivates new mathematical understanding.

4. You're clearly passionate about outreach. Can you tell us more about what you've done and why you love it?

   I have been hugely lucky to speak at some incredible events. Many of them have been recorded and can be found at
   http://thomaswoolley.co.uk/outreach.html

   Two stand out events were being asked to open the Athens Science Festival and speak at the Museum of Mathematics in New York. Absolutely wonderful to speak to such diverse audiences about fun mathematics.

   But why do I love it? It's the "lightbulb" moment that you see in people when they put all the pieces together. In that moment they see the beauty of maths than we often talk about. Specifically, they understand how the fun maths that you're presenting links to the real world, so whether it is using knots to understand transport routes, or zombies to understand pandemics they get something new.

5. What is your favourite research paper (by another mathematical biologist)?

   A Volkening, B Sandstede. Modelling stripe formation in zebrafish: an agent-based approach. Journal of the Royal Society Interface 12(112):20150812, 2015.

   I was lucky enough to be the reviewer of this paper and it is a tour de force of modelling and application. Moreover, it is beautifully written and the introduction is an absolute masterclass of mathematical modelling through biological justification. Each step of abstracting the biology to a mathematical system is carefully discussed and evidenced and any step that cannot be strictly justified is highlighted as a point to be considered later.

   This is a crucial aspect that I wish more math bio people would do. Unevidenced parts of a model shouldn't be hidden. Hiding features makes it feel like your model is weak and will make me be more critical of the results. If you highlight the unjustified areas then it allows me to be more confident in the results, because I don't feel like you're trying to con me.

6. Have you encountered any surprising results in your research?
   The best surprise I ever got on a piece of work involved connecting cell protrusions to cell movement, which was backed up with some lovely data. The biggest surprise was that although we started off with a huge impenetrable model of differential equations that required careful numerical solving due to singularities at boundaries, a few simplifications led to a completely solvable algebraic system that captured all of

the main biology and dynamic effects. It was a wonderful feeling of the maths going from opaque to translucent in just a couple of lines.

7. What advice would you give to a junior mathematical biologist?
   Don't rush your first paper. Academia can be a bit of treadmill of "what's the next idea"? By taking your time with your first paper you ensure that it is well written and you delay your start on the publishing cycle.

8. How do you find working across disciplines? What are the challenges?
   I love it. Did you know that a koala's fingerprints and indiscernible from a human's? I didn't until I'd worked with collaborators on a fingerprint model. This is not a thing I would ever get to know by simply being a mathematician and I love growing my knowledge in new and unexpected directions.

   The biggest challenge has been Covid-19. As a mathematician I need a pencil, paper and a computer. My experimental colleagues need animals, microscopes, labs, reagents, etc. So whereas the pandemic didn't really stop my ability to work it has shrunk my collaborator network. Thus, my current challenge is growing my network to find new and interesting problems.

9. What is the best part of being a mathematical biologist?
   Straddling the disciplines and gaining an extremely eclectic set of knowledge.

10. Finally, how do you spend your weekends?
    Looking after children, *sigh*. However, my wife and I have a system that we alternate Sunday mornings. During her Sunday's she gets to do her craft of choice, whilst on my Sundays I do archery. I started during the first year of the pandemic and I am really enjoying it. I'm currently a third-grade bowmen.