

## **Lorenzo Signore**

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**UROP: Summer 2020** (undertaken in the Dept of Mathematics)

**A Perspective:** A Stochastic model of Neisseria Meningitidis

When I came to Imperial two years ago I only knew I had a sincere passion for my subject, maths, and although I felt like I did not fit that well (the impression was that everyone was much better at it than me) I enjoyed learning, and not understanding immediately but then having a Eureka moment. I finished my first year much better than I expected and won a prize for the end of year research project on Morphogenesis. I was happy with myself and even though it was more literature reviewing than proper research I decided that it somehow fitted what I had in mind when I first entered in maths as opposed to, say, investment banker or software engineer.

Then second year came along, everyone was talking about summer internships, so I decided to look into UROP, following what I realized previously. I turned to the same supervisor I had for the earlier research project, Dr. Bertrand, as he had always been very patient and present when I was not understanding properly something or simply lacked inspiration.

He talked about this modelling project which I was not convinced of at the very beginning, I later discovered that it was because I lacked the instruments to realize what potential impact it could have if the results were what we hoped for. I completed the application form and even managed to get the ESPRC Bursary.

In order to prepare for this project, I attended a 3<sup>rd</sup> year course on Complex Systems Theory in addition to my regular courses. It was rewarding albeit difficult and I thought it had prepared me quite well. I was even more motivated by the fact that I was being funded.

The research could be divided into two parts: Analysis and Simulation of the model my supervisor had in mind. I started with Analysis since my preparation was mostly in that direction. Things became very difficult very quickly. I struggled to make advancements for some time, specifically I could not find a differential equation describing the evolution of the probability density of the variable we had in the model (position, state) and got quite discouraged, the fact that I was not in office but at home because of Covid-19 also did not help motivation, at this critical moment my supervisor has been very understanding and supportive. I also asked him to give a look into it and since he could not readily find himself a suitable direction to advance, he advised me to turn to simulation instead.

There started the productive part of the project, I significantly developed my understanding of how computers work (I had to install a new operating system in order to use some code my supervisor supplied me) and started analysing results of the simulations, learning and using an array of mathematical techniques which can be used in a great variety of settings. Since I was feeling like I was starting again I decided to do 11 weeks instead of the initial 8, and even though not always smoothly, step by step I obtained everything we were hoping to expect.

On the last days I connected more with my supervisor, we discussed much more casually but always with the project in mind, at the very end I also had to brief a PhD student who would be taking on the project, we did a zoom call between the 3 of us and at some point decided to turn to analysis for a brief moment. He had come up with some equation, but it was not yet in a tractable form. While the two of them were trying to get to a solution I had that Eureka moment I was talking about earlier. Observing that not quite successful attempt from the more experienced student I suddenly gained an understanding of the model I did not have for the earlier two months and a half. I came up on the spot with the equation I had been yearning for. Both were very happy and it was a very rewarding way to finish the experience.

Sometimes I wish I had done more, because I could have; at the same time, I am confident that this experience gave me the instruments to not let a deadlock have the best of me, this is specifically true for future research. I am thankful for that.