

Project Title	Maintain socially distancing: Do viruses control the origins of multicellularity?
University (where student will register)	University of Warwick
Which institution will the student be based at?	As above
Theme (Max. 2 selections)	Climate & Environmental Sustainability <input type="checkbox"/> Organisms & Ecosystems <input checked="" type="checkbox"/> Dynamic Earth <input type="checkbox"/>
Key words	Multicellularity, cyanobacteria, viruses
Supervisory team (including institution & email address)	PI: Richard Puxty, University of Warwick Co-I: Orkun Soyer, University of Warwick, Dennis Nürnberg, Freie Universität Berlin

Project Highlights:

- Uncover the role of viruses in driving the onset of multicellularity
- Combine cutting edge molecular microbiology and imaging techniques

Overview:

Multicellularity has evolved numerous times, not only in Eukaryotes, but also within the Eubacteria. There is therefore near universal selection driving social cooperation between individual cells in the tree of life.

Cyanobacteria arose ~2.5 billion years ago, producing all free oxygen on Earth, and seeding the formation of plants through endosymbiosis. It is thought that the last common ancestor of all Cyanobacteria was multicellular¹. Today, within Cyanobacteria, diverse forms of multicellularity exist (Fig. 1). These include filaments, and colonies composed of sheets and spheres. Higher order cooperation also exists, in the form of photogranules, which in some cases, can propel a cm sized colony toward light. Moreover, individual cells can specialise, forming nitrogen-fixing heterocysts, or stress resistant spores called akinetes, which sacrifice themselves for the good of the colony. Many of these social behaviours are facultative, meaning the colony can switch-on or off in response to stimuli.

Whilst the function of these forms of multicellularity are thought to be well understood, the genetic underpinnings and how these early interactions began to evolve remains completely unknown. A popular hypothesis states that simple single-celled organisms began to form colonies to protect themselves from grazing, whereby the cells in the interior of the colony are offered protection. Indeed, in simple laboratory experiments, usually unicellular algae, arrange themselves in multicellular structures in the presence of a ciliate grazer².

Conversely, bacteria are also susceptible to viruses. These viral epidemics are normally thwarted by spatial isolation between bacterial cells. When bacteria are isolated, diffusion constants of the virus

limit transmission, protecting the population. Thus, like in humans, social distancing prevents viral transmission.

Therefore, early initial interactions between cells forming a colony are at risk from being wiped-out by a virus. How multicellular bacteria avoid the viral trap is completely unknown.

During this project, you will seek to understand whether multicellular Cyanobacteria can resist viral infection. You will use model strains of multicellular Cyanobacteria to isolate and characterise viruses against different host morphotypes. You will combine this with time-lapse microscopy to visualise how progression develops, and whether infection causes large scale behaviour change in the colony.

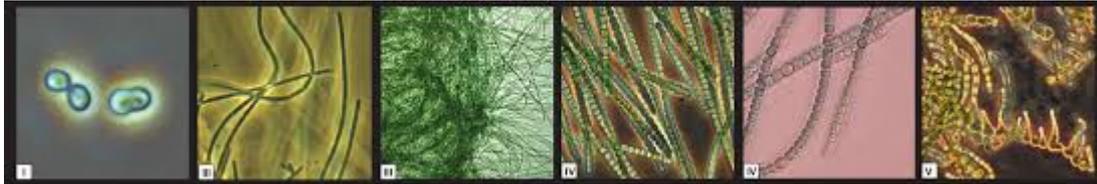


Figure 1: Diverse forms of multicellularity formed by Cyanobacteria (<https://www.palaeocast.com/episode-16-multicellularity-in-cyanobacteria/>)

Methodology:

You will use a combination of classical microbiology and genetics combined with cutting-edge, live-cell, time-lapse, fluorescence confocal microscopy.

Training and skills:

Training will be provided in the above techniques that have been developed in the Puxty and Soyer labs. Many of these techniques will involve transferable technical skills including use of microscopy and genetic manipulation.

Students will be awarded CENTA2 Training Credits (CTCs) for participation in CENTA2-provided and 'free choice' external training. One CTC equates to 1/2 day session and students must accrue 100 CTCs across the three years of their PhD.

Partners and collaboration (including CASE):

The supervisors are world-leading experts in marine molecular biology. We frequently publish in high profile interdisciplinary journals and field specific high impact journals. You will belong to a larger group of environmental microbiologists in the department of life sciences' environment theme. (<https://warwick.ac.uk/fac/sci/lifesci/research/envbiosci/>). These groups occupy a large shared lab area and as such there is continuous collaborations and opportunities for career development within the theme. Current research in the groups is funded by NERC and generous start-up award to Dr. Puxty.

Dr Puxty's group: <https://warwick.ac.uk/fac/sci/lifesci/people/rpuxty/>

Prof. Soyer's group <https://warwick.ac.uk/fac/sci/lifesci/research/osslab/>

COVID-19 Resilience of the Project:

Should COVID delay lab work, an alternative approach will be used that seeks to use metagenomics data to screen for viruses that infect multicellular Cyanobacteria.

Possible timeline:

Year 1: Isolation and characterisation of viruses against different cyanobacterial morphotypes

Year 2: Live cell fluorescence microscopy of infections

Year 3: Test the affects abiotic and biotic stresses on infections. Preparation of publications

Further reading:

Journal:

¹Schirrmeyer et al., 2011. The origin of multicellularity in cyanobacteria. *BMC Evolutionary Biology*, **11**, 45

²Herron et al., 2019. De novo origins of multicellularity in response to predation. *Scientific Reports*, **9**, 2328.

Further details:

Applicants from the UK or the EU are eligible. Applicants should hold a BSc and/or MSc degree in relevant subjects. **Informal enquires** can be made to Dr Richard Puxty (r.puxty@warwick.ac.uk) or Prof. Orkun Soyer (O.Soyer@warwick.ac.uk). Details of how to apply can be found at <https://warwick.ac.uk/fac/sci/lifesci/study/pgr/studentships/nerc-centa/>