

Integrating Synthetic Biology and Single Molecule Biophysics: A Cross-Disciplinary Workshop for Advancing Biotechnological Applications

Introduction

With recent international efforts on sustainability and reducing carbon emissions, the transition to a green industry is more imperative than ever. Synthetic biology aims to tackle this issue using biological organisms modified using engineering principles. Synthetic biology has the potential to replace current petroleum-based industrial processes, thereby reducing carbon emissions. For example, synthetic biology could be used to develop new methods for producing fuel, food, and fabrics with a low carbon footprint.

Event aims

Despite recent advancements, predicting the performance of a newly designed synthetic genetic circuit remains challenging. To fully realise the potential of synthetic biology, we need to develop improved methods for predicting the performance of synthetic genetic circuits.

Single-molecule techniques provide detailed kinetic information on heterogeneous interaction of biological molecules, which could provide a valuable approach for predicting the performance of synthetic genetic circuits. While commonly used in combination with genome engineering, we believe single-molecule techniques can be significantly enhanced when combined with concepts in synthetic biology such as high-throughput experiments or machine learning-based approaches.

This workshop aimed to foster groundbreaking synthetic biology research in the UK, Korea, and Japan by facilitating collaboration through a three-day workshop in the UK. As synthetic biology gains international prominence, it is likely to attract a wide range of researchers. The presence of the Institute of Sustainability at Surrey, a pioneering institution in its field, was instrumental in promoting the workshop. It also created new international collaboration opportunities for synthetic biology researchers at the University of Surrey.

Organisers

The workshop is organised by Dr Wooli Bae at the University of Surrey, Dr Cherlhyun Jeong in KIST and Professor Won-Ki Cho in KAIST.



Dr Wooli Bae



Dr Cherlhyun Jeong



Professor Won-Ki Cho

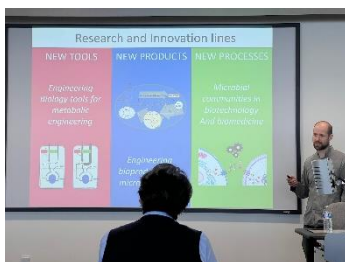
Overview of the programme

The programme was divided into two main themes – synthetic biology and single-molecule biophysics. Synthetic biology was the focus of Day 1, while single-molecule biophysics was the main

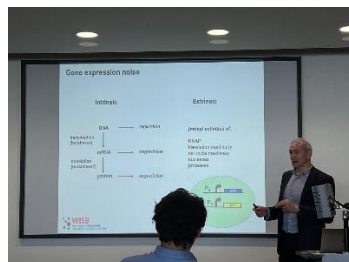
theme for Day 2. We aimed to introduce a wide range of topics within each theme. There were 12 invited presentations, 30 presentations and 50 participants.



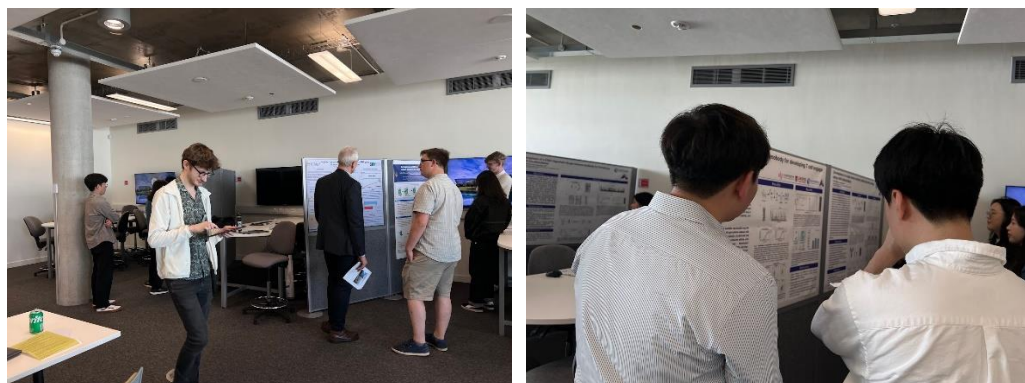
We had two sections on synthetic biology: experimental and theoretical. The keynote speaker, Dr Rodrigo Ledesma Amaro from Imperial College London, opened the workshop with his work on synthetic biology for food. His research centred on metabolic engineering of yeasts to produce vitamins, nucleosides, and lipids. He also shared his recent contributions to industrial applications and collaborations with charity funding agencies.



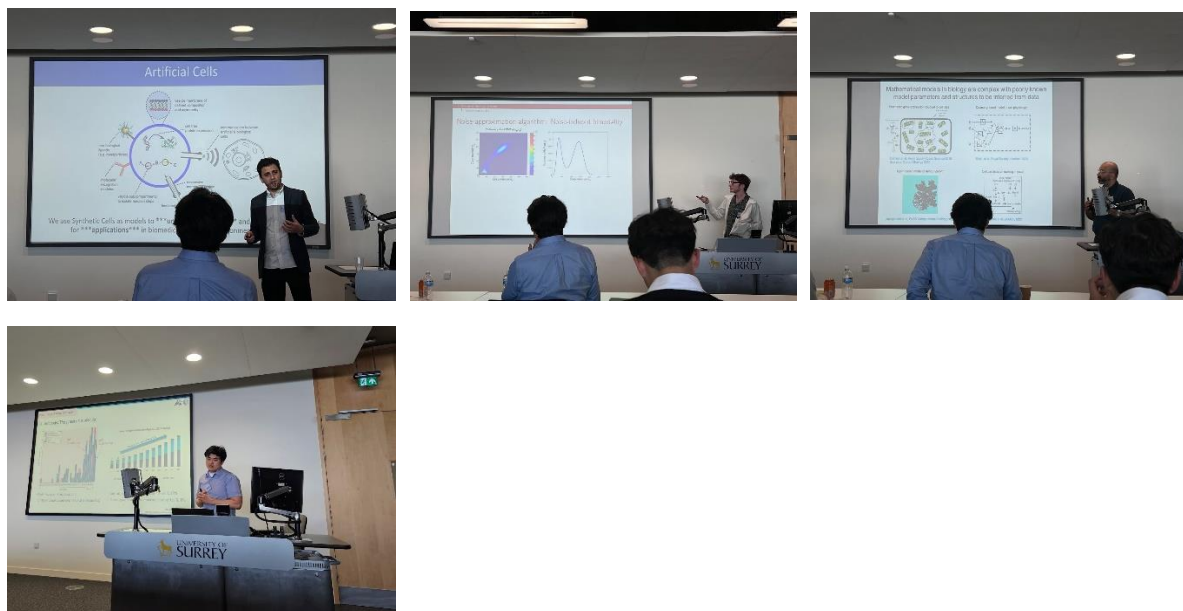
Following flash presentations from poster presenters, we had a short coffee break before the presentation by Professor Hiroki Ueda from the University of Tokyo. He shared his research breakthroughs in identifying chemical agents for clearing entire organisms. Professor John McCarthy from the University of Warwick continued the session with presentations on the effects of stochastic processes in microorganisms.



The lunch session was followed by a 1.5-hour poster session focused on synthetic biology. Over 15 posters from early-career researchers, such as PhD students and postdocs, showcased their research projects and latest findings. There was much positive feedback from the poster presenters, who valued the interactions and discussions during the session.



In the afternoon synthetic biology session, Dr Yuval Elani from Imperial College introduced his state-of-the-art microfluidic system. His device produces artificial vesicles with defined shapes and compositions to mimic crucial cellular structures. The session continued with two theoretical presentations from Dr Tomislav Plesa from the University of Cambridge and Dr Vahid Shahrezaei from Imperial College London. Dr Plesa presented his mathematical frameworks for generating various synthetic biological states, while Dr Shahrezaei shared his deep learning models for synthetic biology systems. Professor Jung-Hyun Na concluded the session with his recent work on developing novel antibodies.



On Day 2, the workshop resumed with a presentation from keynote speaker Professor Jongbong Lee from POSTECH, who shared his research on revealing the mechanisms of DNA repair machinery using single-molecule fluorescence. Professors Jae-Hyung Jeon and Min Ju Shon from POSTECH continued the discussion with their work on mathematical modelling of biomolecular reactions and magnetic tweezers experiments on membrane protein folding pathways. After a coffee break,

Professor Inwha Baek from Kyunghee University presented her latest advances in single-molecule imaging of RNA polymerase activities. Our final invited speaker was Professor Won-ki Cho, who shared his research on identifying protein clusters in the nucleus.



During the lunch, we also hosted a 1.5-hour poster session on single-molecule biophysics. There were more than 15 posters.

Reflection from the participants

There were a lot of positive comments from the participants, especially from the early career researchers. The participants also enjoyed how nice our campus at Surrey was. Three major points were

- Number of interactions coming from the fact that all the meals and accommodation was provided
- The wide range of topics
- The quality of the presentations

"This work is well organised in a beautiful campus in Guildford" - Professor Won-Ki Cho

"I am happy with the amount of discussion and interaction I had during the poster session" - Dr Javier Cabello Garcia

"The venue was so nice and I liked that fact that everything occurred in one site for focused discussions" - Professor Inwha Baek

Next Steps & Outcomes

After a successful workshop at Surrey, the organisers have decided to host a second workshop with the same theme in Korea in March 2025. The second workshop will focus on strengthen the existing networks established in the first workshop and building new networks. We do not have specific plan for publication yet.

Acknowledgements

We would like to acknowledge support from our sponsors

- The Institute of Advanced Studies at the University of Surrey
- British Embassy Seoul
- Biotechnology and Biological Science Research Council
- National Research Foundation of Korea
- Korea Institute of Science and Technology

We would like to thank for administrative and technical support from Louise Johns, Natalia Diaz Romero, Mirela Dunic, Sharon Welland and Samia Bakhtawar. The event would not be possible without their fantastic support.