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**IOP** | Institute of Physics  
**Physics in Food  
Manufacturing Group**

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**NEWSLETTER**

**February 2020**

**Issue no. 3**



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See <http://www.iop.org/activity/groups/subject/pifm/index.html> for further details

Our next conference [Food Physics 2021](#)

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## Chair's report

Welcome to the third newsletter of the Physics in Food Manufacturing group.

We have just had our fourth conference in the series “Physics in Food Manufacturing” hosted at Leeds University (Jan 2020). This is the first conference supported by another IOP group, Liquids and Complex Fluids, so many thanks to their group chair Sergey Lishchuk. Particular thanks due to Megan Povey for leading the organising committee and putting together our longest conference to date at 2½ days with our most International programme, including a lively early careers panel discussion. Read more in the conference report including prizes for best student poster and presentation.

I'm also delighted to report PiFM had our first AGM, where we agreed to change the group name to **Food Physics**, there will be formal communication to follow in 2020. Read the AGM report for more details.

Our very own Megan Povey was featured in the Careers section of Physics World (Jan 2020), well worth a read. Digital edition of the magazine article [here](#).

After 4 excellent conferences hosted by Universities (Sheffield Hallam 2017, Edinburgh 2018, Leeds 2020) and Industrial-facing institutes (Campden BRI 2019), I'm delighted to confirm that our next conference (**Food Physics 2021**) will be hosted at IOP HQ in London (2 & 3 Feb 2021).

Visit [Food Physics 2021](#) for more information on the conference.

In the spirit of strengthening links with other groups, PiFM is partnering with the Royal Society of Chemistry's Food Group to host a joint one-day conference entitled “Chemical and Physical Modelling of Food” on 21 Oct 2020. Read more later in this newsletter.

PiFM committee members were busy again at various external food and physics conferences during 2019, with several of the committee organising and presenting their perspectives and research, read more of this later.

2019 was also a year of change for the committee. Wilson Poon, Thomas Krauss, Sarah Bridle and Anne Pawsey stepped down, and I thank them all for their significant contributions during their tenure. Wilson was also recognized for his outstanding contributions in soft matter physics during 2019 – [Sam Edwards Medal](#) and [Thomas Graham Award](#), and I'm delighted he's provided a guest editorial for this newsletter.

A very warm welcome to new committee members Dr Arwen Tyler (Leeds Uni) and Dr Daniel Hodgson (Edinburgh Uni).

The launch of the [National Food Strategy](#) is due early 2020, after a consultation period in 2019. PiFM contributed on behalf of the IOP to a “Professional Body” submission led by the RSC. As has been said many times before, the food industry faces many challenges and opportunities requiring multidisciplinary and collaborative partnerships with other learned societies, so it’s reassuring to see this in action again.

We continue to encourage all readers to engage with PiFM / Food Physics, whether to discuss joint workshops / conferences, link us to events perhaps outside our normal networks, or just to discuss application of interesting physics to solve food and drink innovation challenges.

John Bows, Chair

## Guest Editorial

“Physics and food” has a venerable history. The December [issue](#) of the second volume (1949) of the APS magazine *Physics Today* carried an article entitled “Food Physics”. The IOP caught up in 1968 with an [article](#) on “Physics in Food” in *Physics Bulletin* (now *Physics World*). Significantly, both were written by physicists working in industrial food research labs, so that both articles emphasized the application of the principles and techniques of physics to food manufacturing, such as the conduction of heat through complex structures and techniques for characterising these complex structures.

The application of physical principles and techniques to all aspects of food manufacturing remains central to this interdisciplinary area. However, external and internal factors have combined to broaden its scope since those early days. Externally, there has been unrelenting pressure to focus on the individual consumer. Food physics from the consumer’s perspective was already hinted at in the early literature, where there was palpable excitement for the potential of using microwaves not only in manufacturing, but also in the domestic kitchen; the rest, as they say, is history. The physics of cooking has become a veritable growth industry with the rise of “molecular gastronomy”. The emphasis here is quite different from manufacturing – making a soufflé is (usually!) a private activity; but thermodynamics has just as much to say about it as about (say) the drying of cornflakes. Studying the physics behind mouth feel is also consumer-driven: the mechanics of mastication, oral tribology, the sound made by fracturing foodstuff and much else are all legitimate topics for physics-based research, but establishing a comprehensive framework for the “psychophysics of food perception” remains a (lucrative?) challenge. The most important development within physics with food implications is the rise of soft matter physics, which coalesced into a distinct subfield during the 1980s. Much of the contents of the handy introductory text *The Chemical Physics of Food* edited by Peter Belton could easily be classified under this heading. The distinctive perspective of this area, a judicious combination of generic probing of classes of materials with attention to chemical details in particular cases, has been applied to food ingredients from the beginning, and increasingly to complex foods themselves.

An area of food physics that has so far received perhaps less attention is sustainability, a subject on which our very survival depends. Focussing on this area can lead physicists surprisingly far afield. There is, for example, a 2018 publication emanating from an earlier conference in China entitled “Advancing Soil Physics for Securing Food, Water, Soil and Ecosystem Services”. But one does not have to venture that far afield to find fertile ground for sustainable food physics. Energy use in food manufacturing, transport, distribution and cooking is

at the core of sustainability. Based on the tremendous advances in all aspects of food physics over the last 50 years, one can surely imagine ways of cutting down the carbon footprint of these activities. A big challenge here is that three of the most relevant quantities for the energetics of food, the specific heat capacity of H<sub>2</sub>O and its two latent heats, are well known to be anomalously large (compared to, say, H<sub>2</sub>S). However, a 30-minute exercise in order-of-magnitude calculations will quickly show that boiling only a single cup of water for a single cup of tea (rather than half filling the kettle) will make a noticeable contribution (a few percentage points) to the UK's domestic electricity consumption. A 'Citizen's Science' project on sustainability in the kitchen (see p. 15) can therefore make a real difference. Watch this space!

Wilson Poon

## **PiFM Purpose**

Supporting research into areas of physics that impact on the food sector and encouraging collaborative research between academic and industrial physicists.

Promoting the role of physics in the food industry and ensuring that it is more widely understood that this is a field in which there are opportunities to conduct interesting and important research; promoting this fact to early career physicists and policy makers.

Providing a mechanism for physicists in the sector to feed into the IOP and have their views represented to funders and policy makers.

## **Activities**

Organise an annual conference

Engage with physics academia / other IOP groups e.g. host joint events

Bidirectional exchange of physics and problems between industry and academia

Engage beyond IOP (e.g. IChemE, RSC, STFC Food Network, IUK)

Publish newsletters

Engage early careers physicists

## Report from PiFM Conference, 15-17 Jan 2020

Conference website with abstracts and programme downloads:

<http://foodphysics2020.iopconfs.org/Home>

The conference was characterised by a uniformly high level of physics applied to a diverse range of real-world problems in food manufacturing. Given the challenges that the food industry will face over the coming decades it is good to know that there is a science cadre, by no means all physicists, who can address complex problems in the processing of the heterogeneous materials and almost all states of matter that make up foods.

Subjects that stick in my memory particularly related to “soft colloidal microgels” and “viscosity modelling”. Sessions were held on “Complex fluids and rheology”, “Crystallisation” and “Measurement science challenges”. “Physics in digestion”, “Colloid Science” and “Physics of Macromolecules”. The sessions had an underlying theme of flow, influenced by joint sponsorship of the conference by the IOP Liquids and Complex Fluids Group. The importance of the relative contributions of Brownian motion, yield viscosity and jamming behaviour (particle contacts) in the stability and functionality of colloidal systems and particulate systems was quite a theme of the conference.

The conference for me demonstrated the unifying power of physics for helping to understand the world, the diversity of participants is something that we must build on for the future. Our approach to physics must become far more inclusive if it is to make the contribution necessary to meet the tests we face.

A disappointing aspect of the conference was the lack of attendance from SME's (Small and Medium Size Enterprises). It is important for us to address this issue because the food industry is dominated (both in terms of employment and turnover) by SMEs. It is also clear that the multidisciplinary challenges we face necessitate collaboration with other learned societies such as the SCI, the RSC and food industry bodies such as the Food and Drink Federation (FDF). One suggestion is to continue with the two-and-a-half-day format but address one day to issues raised by SMEs. Another lesson is that the program (subjects and plenary speakers) needs to be advertised at least six months before the event!

A [conference review](#) was published by IOP on physicsworld.com:

The next conference will be held at IOP HQ, London, 2-3 February 2021.

Megan Povey

## Early careers panel discussion



A very successful panel discussion on early careers addressed the question of reimagining food production in a sustainable world, the discussion was dominated by young people, both from the panel and from the audience.

Finding a mentor who would support and champion a postgraduate's course through the early stages of a career was highlighted.

The panel was chaired by Beccy Smith (Mondelēz) and comprised a very diverse group of young people: Zac Glover (University of Southern Denmark), Ayoub Kadoussi (Malvern Panalytical Ltd), Teresa Roncal-Herrero (Leeds post doc), Yue Ding (Leeds postgrad) and Xiaodong Zhai (Jiangsu University, Zhenjiang, China)

Two student prizes were awarded:

**Best student presentation:** Daniel Hodgson, University of Edinburgh. Chocolate to couscous: a unified treatment of granulation and suspension rheology.



*John Bows congratulating Daniel Hodgson*

My presentation looked at the link between the physics of granulation and suspension rheology. Granules are engineered particles used in a wide range of sectors for many reasons, including improving the handling of fine powders and for the production of food products such as couscous. Granules are formed by adding small volumes of liquid to dry powder and agitating the mixture. At the other end of the spectrum, suspensions are formed by adding small amounts of powder to liquid. The two end states are typically studied in isolation, despite appearing to lie at two ends of a continuum of solid content.

In this presentation I showed that indeed suspensions transition to granules above a critical jamming volume fraction, and that for shear-thickening suspensions, this jamming volume fraction is stress controlled. Using this new understanding, I showed that conservation of mass arguments could be used to construct a model for granule size with a single free parameter, showing good agreement with the experimental data.

I would like to thank the conference organisers for this opportunity to present my work and look forward to working with the IoP Food Physics Group in the future.

Daniel Hodgson

**Best student poster:** Andrea Araiza-Calahorra, University of Leeds. Evaluating the fate of microgel-stabilised Pickering emulsions during in vitro gastric digestion: role of electrostatic coating versus covalent-conjugation with polymers.



Recently, particle-stabilized emulsions, also referred to as Pickering emulsions (PEs) have attracted significant research attention. However, designing PEs as delivery vehicles using natural, biodegradable particles that offer gastric stability faces new challenges in food colloid science.

The aim of this study was to design novel protein-based soft gel particles as Pickering stabilizers for specifically generating 'gastric-stable' PEs. By using electrostatic and covalent interactions between whey protein and biopolymer (dextran), a bottom-up approach was used to design three different

types of Pickering emulsions (20 wt% oil); whey protein nanogel particle-stabilized PE12, dextran sulphate (DxS)-coated whey protein nanogel-stabilized PE2 (using electrostatic coating of DxS of 40-500 kDa molecular weights), and whey protein-dextran conjugate microgel particle-stabilized PE3, latter using different degrees of conjugation with dextran before the microgel creation. Complimentary techniques ranging from static and dynamic light scattering, interfacial shear

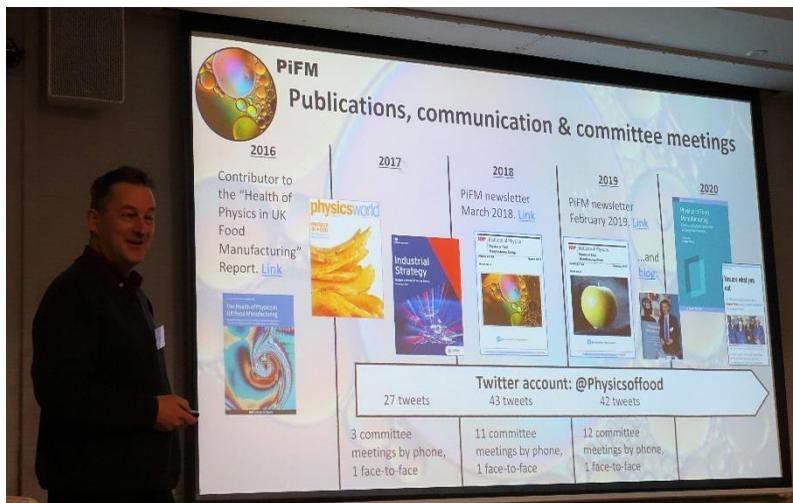
reology, confocal and cryo-scanning electron microscopy, zeta-potential, sodium dodecyl sulphate polyacrylamide gel electrophoresis (SDS-PAGE), ortho-phthaldialdehyde (OPA), pH-stat to cross-correlation image analysis of the particles and the PEs allowed to compare the behaviour of the PEs, pre- and post-digestion.

Under *in vitro* gastric conditions, both electrostatically-coated PE2 and conjugate microgel-stabilized PE3 presented a diffusive barrier to the pepsin-hydrolysis of the underlying protein particle-laden interface, which consequently delayed the interfacial proteolysis. In both PE2 and PE3, droplets were resilient to gastric coalescence unlike the unmodified PE1. Under *in vitro* intestinal conditions, the amount of free fatty acid (FFA) released was similar ( $p > 0.05$ ) for all the three PEs, whilst, the rate constant and half time of the electrostatically-coated PE2 was the highest and lowest, respectively ( $p < 0.05$ ) owing to droplet aggregation and reduction in surface area for lipase to bind. This study provides new design principles to create PEs with tailored barrier properties to allow developing delivery systems for lipophilic compounds that require targeted intestinal release.

Andrea Araiza-Calahorra

## PiFM AGM

During the conference at Leeds, PiFM held its first AGM. John Bows and Rob Farr presented an overview and history of the group, its publications, external engagements and financial expenditures.



*John Bows (Chair) providing overview of PiFM history*

The main discussion point was around strengthening attendance at conferences, especially from SME food companies and a broader spectrum of Universities (esp. food science/nutrition, food engineering departments). We talked about multidisciplinary partnerships to solve pre-competitive food innovation challenges so we would like to see more professional body attendance, as well as attendees from all large international food company R&D functions.

We discussed whether our name "Physics in Food Manufacturing" appears too focussed on manufacturing (all PiFM conferences have much broader content from physics of digestion to measurement science challenges with a core interest in microstructure), and starting with "Physics" underplays the focus on "Food" (and beverages obviously).

Several motions were proposed:

1. Change our group name from “Physics in Food Manufacturing” to “Food Physics”, passed by 15 with 1 vote against and 1 abstention.
2. Current committee and officers (as listed under Group Committee later in this newsletter) unanimously re-elected.
3. The 2019 accounts were unanimously approved.

Other discussion points

- IOP data shows members of PiFM come from all the IOP groups, with no particular groups being under or over-represented in PiFM membership. This shows the wide appeal of PiFM generally to IOP membership.
- John Melrose took on a new responsibility as Publicity Officer.

John Bows

## Citizens Project

A very entertaining after dinner speech by Wilson Poon resulted in a proposal for a 'Citizen Science' project around sustainable processes in the domestic kitchen.

There are around 20 million households in the UK and many things that go on in the kitchen are wasteful of energy. For example, many of us fill our freezers with unlabelled food, then forget what it is and eventually have to throw it out.

The idea is to involve student projects in Universities and Colleges to provide tools for Citizens to assess the way they use kitchen equipment (Freezers, fridges, stoves, hobs, pressure cookers etc) and the way recycling is conducted in order to optimise use in the domestic kitchen. The ambition is that the project ultimately involves millions of people whose engagement can reduce their energy costs on the one hand and provide them with a scientific approach to improving sustainability.

Even relatively small reductions in each consumer's energy consumption when multiplied by the number of households can have a significant impact. The project could be popularised through social media and the motivation is for it to become the property of millions of people. Thought and resources will be needed to achieve this aim but we need to engage everyone in the pursuit of sustainability if it is to be achieved and the impact of global warming reduced. Watch this space.

Megan Povey

The week following the conference was Big Energy Saving Week 2020 to highlight ways consumers can reduce energy usage and save money.

<https://www.mirror.co.uk/money/20-easy-ways-save-money-21318075>

<https://energysavingtrust.org.uk/big-energy-saving-week-2020>

"The two charities said just one small change, such as only filling the kettle with as much water as you need could save households £1.1billion and stop 2million tonnes of carbon dioxide being released into the atmosphere".

## Physics in Food Manufacturing: Case Studies in Fundamental and Applied Research

Edited by Megan J Povey (University of Leeds, School of Food Science and Nutrition), this new book will be available Q2 2020.

The scope of this book comprises invited contributions against 3 core themes:

- Rheology and complex fluids
- Process engineering and manufacturing
- Measurement science and physical measurement of foods

The coverage reflects the role that physicists play in solving the inherently multidisciplinary science and technology challenges in food manufacturing – from designing safe, nutritious and great-tasting foods to the process technology and manufacturing know-how needed to deliver compelling product innovation. This book is the first authoritative text on the subject, providing a foundational resource for the transformation of engineering and materials characterisation in the food and pharmaceuticals industries. The aim is to create a “go-to” reference source for the global PiFM community – interdisciplinary physical scientists, food/nutrition scientists and engineers working in academic research, government labs and industry. The book will also be a valuable resource for R&D staff and product engineers working for suppliers of specialist instrumentation and equipment to the food processing industry. Beyond research, technology and application, this book will have a role to play in promoting food-sector careers and professional development. Food manufacturing companies need a pipeline of talented scientific and technical staff, so we are keen to raise awareness among physicists that there are interesting careers to be had in the food industry.

Chapter 2 by Denis Flick from Agro Paris Tech is a comprehensive, clearly written and up to date account of the underlying physics and current techniques available for modelling heat transfer in foods. Dr Flick’s group is internationally renowned for their work which is reflected in the Chapter Bibliography.

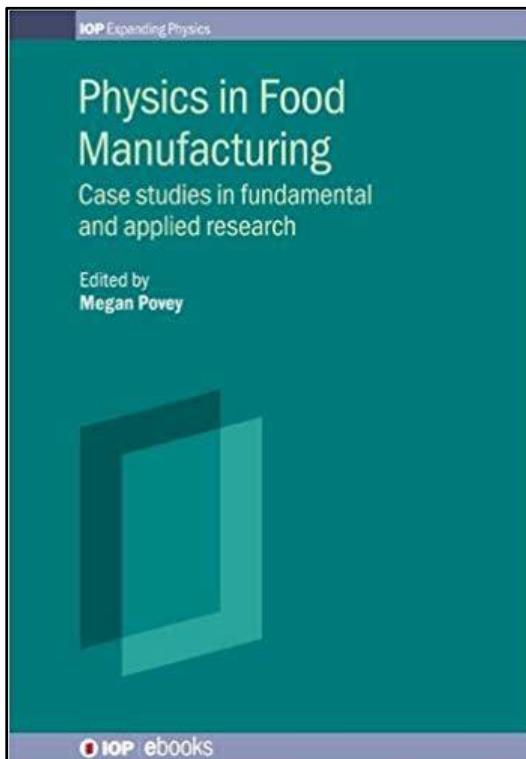
Chapter 3 (Matt Sinnott and colleagues at CSIRO, Australia ) contains some very impressive examples of the achievements of Particle Based Modelling as applied to complex food processing problems such as mixing and heat transfer.

In Models of surface viscosities of particle-laden fluid interfaces (Chapter 4) Sergey Lishchuk outlines computational and mathematical models for the rheology of the complex heterogeneous materials that make up food.

Coffee brewing (Chapter 5 –John Melrose) is a fascinating subject for all coffee lovers and the incredible complexity of the process arising from the complex microstructure, chemistry and physical chemistry of the raw material is detailed here, with lessons for other extractive processes. Chapter 6 is an extension of Chapter 5 in which the extractive process is modelled.

A pioneer of Crystal Engineering approaches to crystallisation in food systems, Elena Simone (Chapter 7) describes novel and potentially far-reaching engineering and modelling approaches to the growth of food crystals. Detailing amongst other things (Lactose, succinic acid, the surprising behaviour of a highly polar polyphenol, quercetin, is described, which nevertheless crystallises in aqueous solution. The chapter begins with a valuable introduction to the fundamentals of crystal engineering

In the final Chapter, Steven Ward-Smith provides a comprehensive description of contemporary measurement techniques for the characterisation of foods.



## PiFM Committee Members at external events during 2019

John Bows presented at the IOP Business Innovation and Growth Group [Conference](#) (26-Feb-2019) on PepsiCo's 2018 Business Innovation Award as well as general physics in food manufacturing.

Martin Whitworth gave a presentation on "The Science of Baking" at the [Edinburgh Science Festival](#) (14-Apr-2019).

The [4<sup>th</sup> Edwards Symposium](#) – Emerging Trends in Soft Matter (4-6 Sep, 2019) – was sponsored by Unilever with a programme highlighting latest developments in soft matter science with a strong fundamental physics focus. In a Soft Matter Industry Challenges session, Rob Farr presented on Soft Matter Challenges in Coffee Processing ([download](#)).

The [Photonics 4 Food Symposium](#) (24 Sep 2019) showcased the latest photonics R&D as applied to the food and drink industry. John Bows presented on Photonics in Food Manufacturing, and Martin Whitworth presented on Imaging Methods for Food Characterisation.

[New Scientist Live](#) (10-13 Oct 2019) was attended by Megan Povey on the [Acoustics Network](#) stall demonstrating acoustic techniques for testing foods, and John Bows was part of the [PepsiCo](#) stand (first time any manufacturer had showcased food).

The [Joint Fall Meeting](#) of the Texas Section of the American Physical Society (Texas State University, Lubbock, 25-Oct-2019) - John Bows was invited to present on PiFM group activities and Physics in Food Manufacturing.

John Bows was invited to write an article for the APS Forum on Industrial & Applied Physics newsletter. *The Need for Physics in Food Manufacturing* (Fall 2019) - <https://www.aps.org/units/fiap/newsletters/201910/food.cfm>

## Chemical and Physical Modelling of Food conference



As part of ongoing efforts to foster links across the sciences, and increase awareness of modelling efforts happening in food industry and research, the PiFM group and the Royal Society of Chemistry's [Food Group](#) will be organising the first joint one-day conference entitled "Chemical and Physical Modelling of Food".

This conference will be covering topics related to chemistry and physics (and anything in between) of food manufacture, preparation and consumption, including measurement, model building and model validation.

Speakers will include both industry and academia, including Mondelēz, PepsiCo, University of Leeds and University of Reading (the full agenda will be finalised soon). Anyone from industry and academia, including students, are welcome to attend what should be a very interesting day.

There will also be a poster session, with prizes being awarded at the end of the conference for both best presentation and best poster. The conference will be held on 21 October 2020 at the RSC's premises at Burlington House, Piccadilly, London.

Visit [conference website](#) for more information on registration and speakers.

John Bows

## Finally Physics

Finally, we highlight exciting food physics stories, experiments, features ...

Cooking with the sun (6-Jan-2020)

<https://physicsworld.com/a/cooking-with-the-sun/>

Physics Can Help Develop New Foods -- Like Crispy Jellyfish Chips (9-May-19)

<https://www.insidescience.org/news/physics-can-help-develop-new-foods-crispy-jellyfish-chips>



BBC Radio. The Physicist in the Kitchen. Can understanding a little chemistry and physics help us cook better? Dan Saladino asks Heston Blumenthal and Raymond Blanc. (27-Jan-20)

<https://www.bbc.co.uk/programmes/m000dpn5>

From our Twitter feed (@Physicsoffood) – thanks to Martin Whitworth ...

[Want to know if spaghetti is al dente? Check how much it curls in the pot](#)

[The Delicate Architecture of Puff Pastry](#)

[Bread machines get a much-kneaded physics makeover](#)

[Vacuum keeps food fresh and cool from field to table](#)

[Taking a bite out of food waste](#)

[Making the Perfect Crêpe](#)

[Chocolate making relies on a rich mixture of physics](#)

[How Frito-Lay Applies Machine Learning](#)

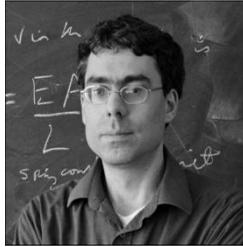
[But the Crackling is Superb](#) – out-of-print book but available second hand

[Yummy Physics](#) – YouTube channel

## Group Committee



John Bows, Chair  
PepsiCo



Dr Rob Farr, Treasurer  
Jacob Douwe Egberts



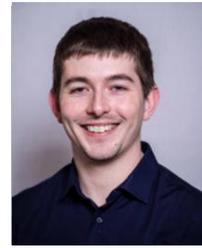
Dr John Melrose, Secretary



Dr Beccy Smith  
Mondelez International



Prof Megan Povey  
Leeds University



Dr Daniel Hodgson  
University of Edinburgh



Dr Arwen Tyler  
Leeds University



Dr Martin Whitworth  
Campden BRI



Prof Doug Cleaver  
Sheffield Hallam University



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