The Future of Food Engineering

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Talk Outline

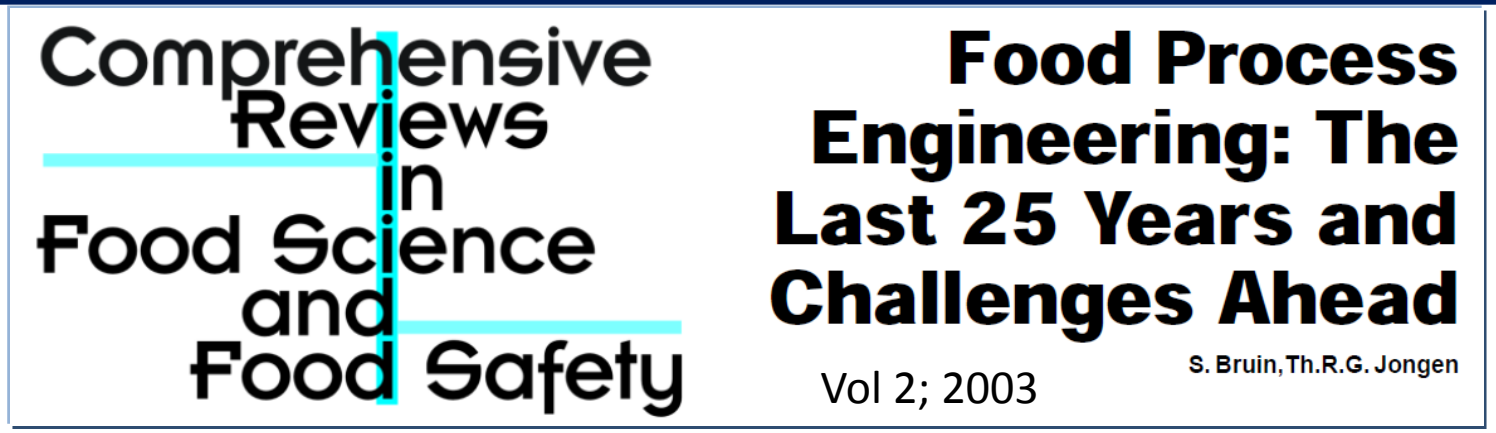
- Evolution of the area
- Drivers for change / innovation
- Current and future landscape
- An exciting & dynamic future

The Changing Face of Food Manufacturing

Challenges and Opportunities Ahead:

- Global Food Security
  (not just growing more food but how to turn it into the food we eat!)
- A move from Nutrition to Sustainability
  (market(ing) drivers, but real opportunities for innovation)
- Personalised Nutrition – Personalised Products
  (moving production closer to the consumer)
- Food manufacturers – Retailer Interaction
  (new supply chain models)

A quick look back



- Raw material modification for functionality that matter to the consumer: nutrition, flavour, structure, colour.
- Value addition moved the industry from MAKE-SERVICE-CARE, with focus on LEAN-AGILE-VIRTUAL manufacturing
- E-commerce, satisfying consumer needs moving the industry more to SERVICE and CARE.
- Unit operations ‘building block’ approach miss opportunities for process innovation.
- Process Synthesis: Understanding data relating to raw materials and process to produce desired products at minimum cost

JM Aguilera +.....

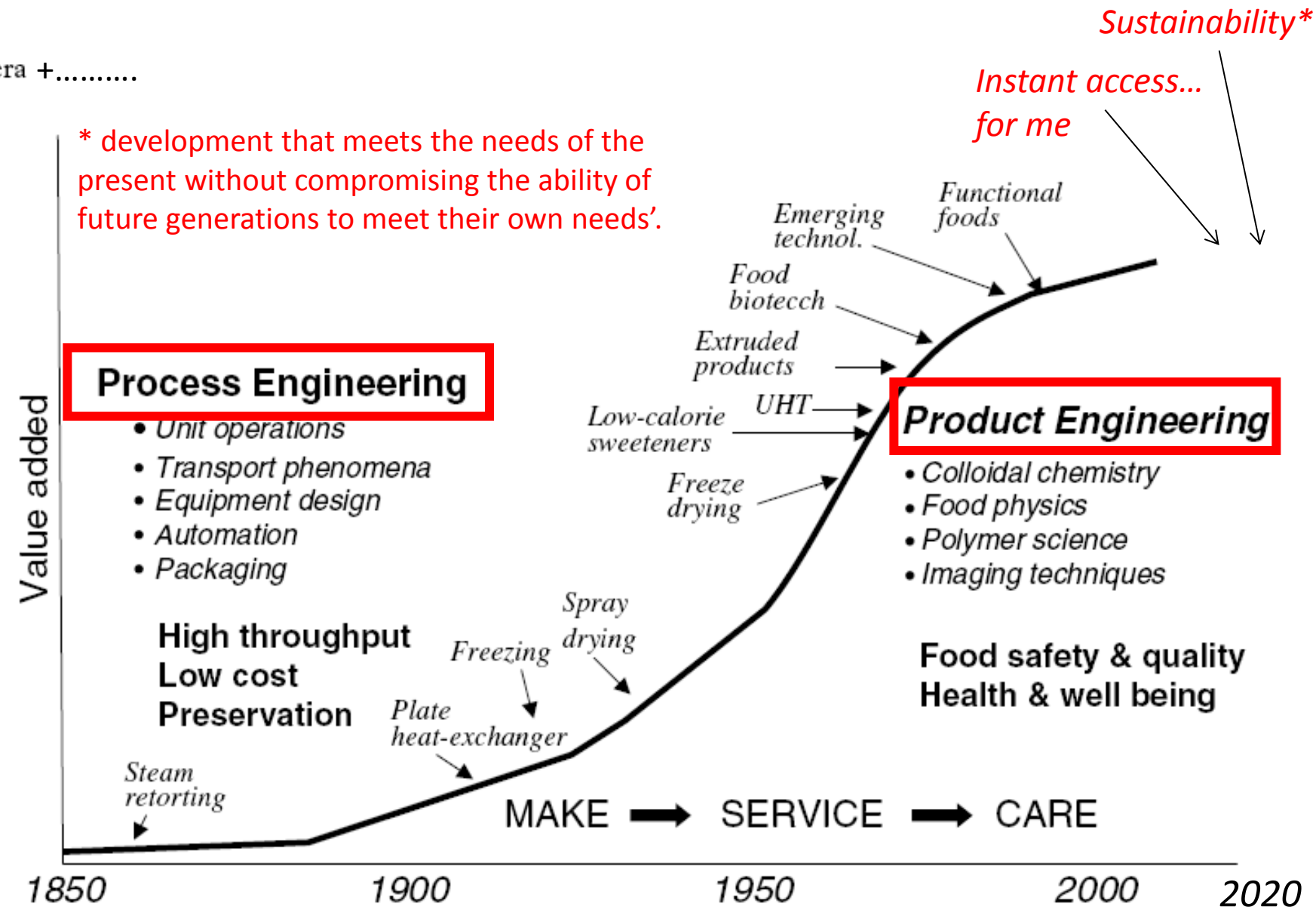


Figure 1. Evolution of the food industry in terms of value added to products and shift in emphasis from process engineering to product engineering. This transition has implied a change in concepts and techniques that support each approach.

Requirements: a step change in the thoughts on process engineering, with the key transformations required in intelligent product design providing targets for novel resource efficient engineering processes.

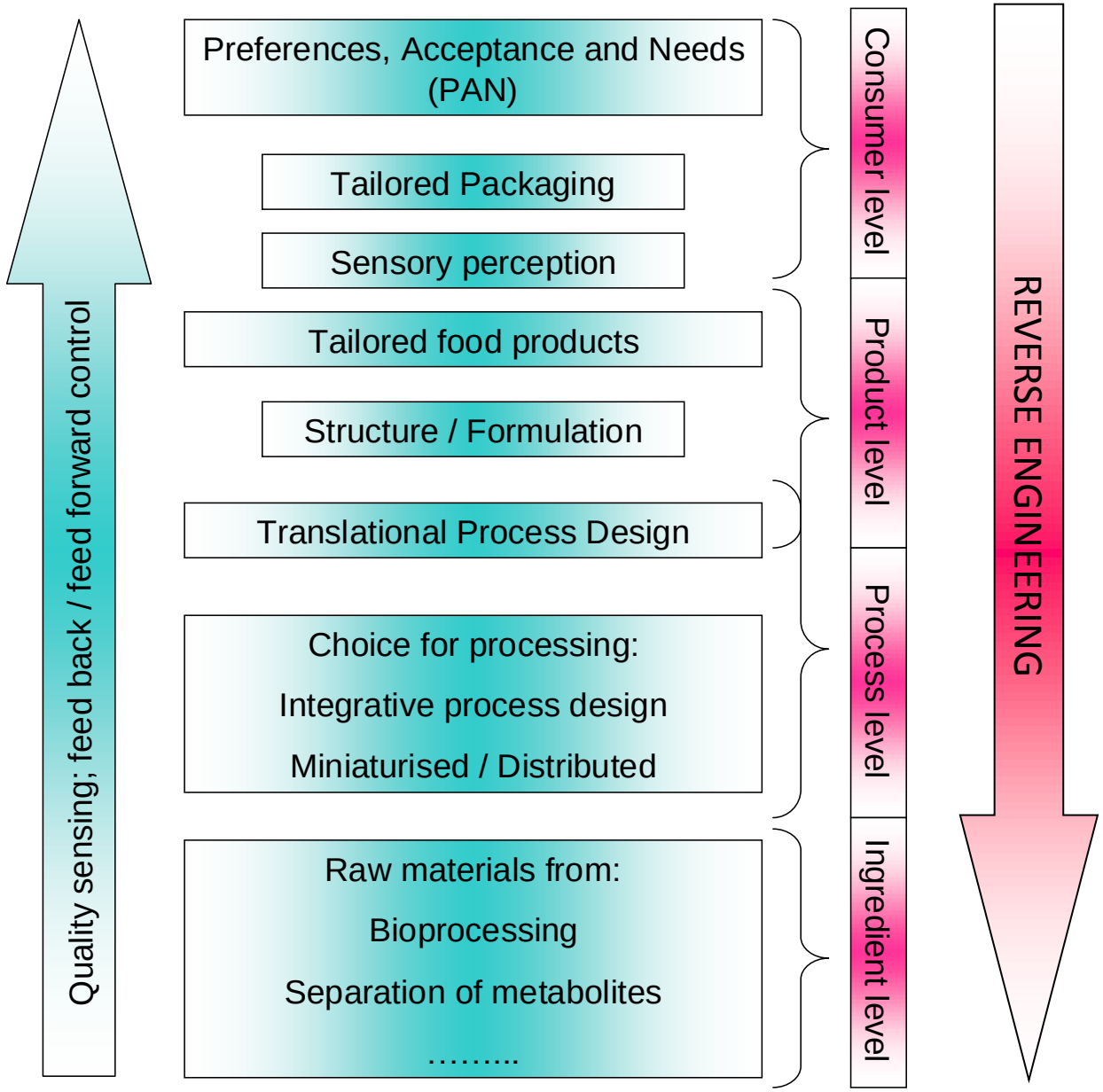
- Bruin and Jongen (2003, Food Process Engineering: The Last 25 Years and Challenges Ahead, *Comp. Rev. Food Sci. & Food Safety*, 2, 42-81)
- Hill (2004, Product and Process Design for Structured Products, *AIChE J.*, 50(8), 1656-1661)
- Saad and Gindy (2007, Future shape of the responsive manufacturing enterprise, *BIJ*, 14(1), 140-152)

where a “Complete rethinking of supply chains will be an important tool to achieve competitive advantage alongside product innovation in a rapidly changing society”, which “suggests the need for a comprehensive framework to systematically design a process to manufacture any given structured product” and a manufacturing enterprise of the future “has to achieve rapid, flexible and integrated development and manufacture of innovative products at a price the customer is prepared to pay”.

- Developing quality food products
- Achieving sustainable food production
- Tailor-made foods to preference / acceptance / needs of consumers
- Entrepreneurial / innovative Industry
- Changing operating procedures
- Small Scale efficient and flexible processing
- Hygienic processing
- Ingredient functionality and security of supply
- Limited water
- Biomass refining
- Food product design and fabrication

'While the old title contained the term "manufacturing", this was considered too narrow to define the field'……
'This approach encompasses the whole life-cycle of processed foods.'
'The concept of farm to fork is too limited, and needs to be expanded to that of **from farm through digestion**.'

Food Quality & Manufacturing



European Technology Platform on Food for Life

Strategic Research Agenda 2007-2020

High Value Manufacturing Landscape

- Trends & Drivers:
  - Increasing cost and scarcity driving importance of security of supply, use of fewer materials and less energy including water for all outputs as well as more reliance on renewable resources.
  - The rise of the digital economy and an associated increase in customised products will have an impact on traditional products. Integration is expected to have more of an influence on innovation than will new R&D.

- National Competencies (2025)
  - Understanding designing and manufacturing formulated products
  - 'Plug and play' manufacturing
  - Design & manufacture for small-scale & miniaturisation
  - Systems modelling & integrated design/simulation
  - Automation, mechanisation and human/machine interface
  - Flexible and adaptive manufacturing
  - Combining product development steps in parallel / concurrent engineering

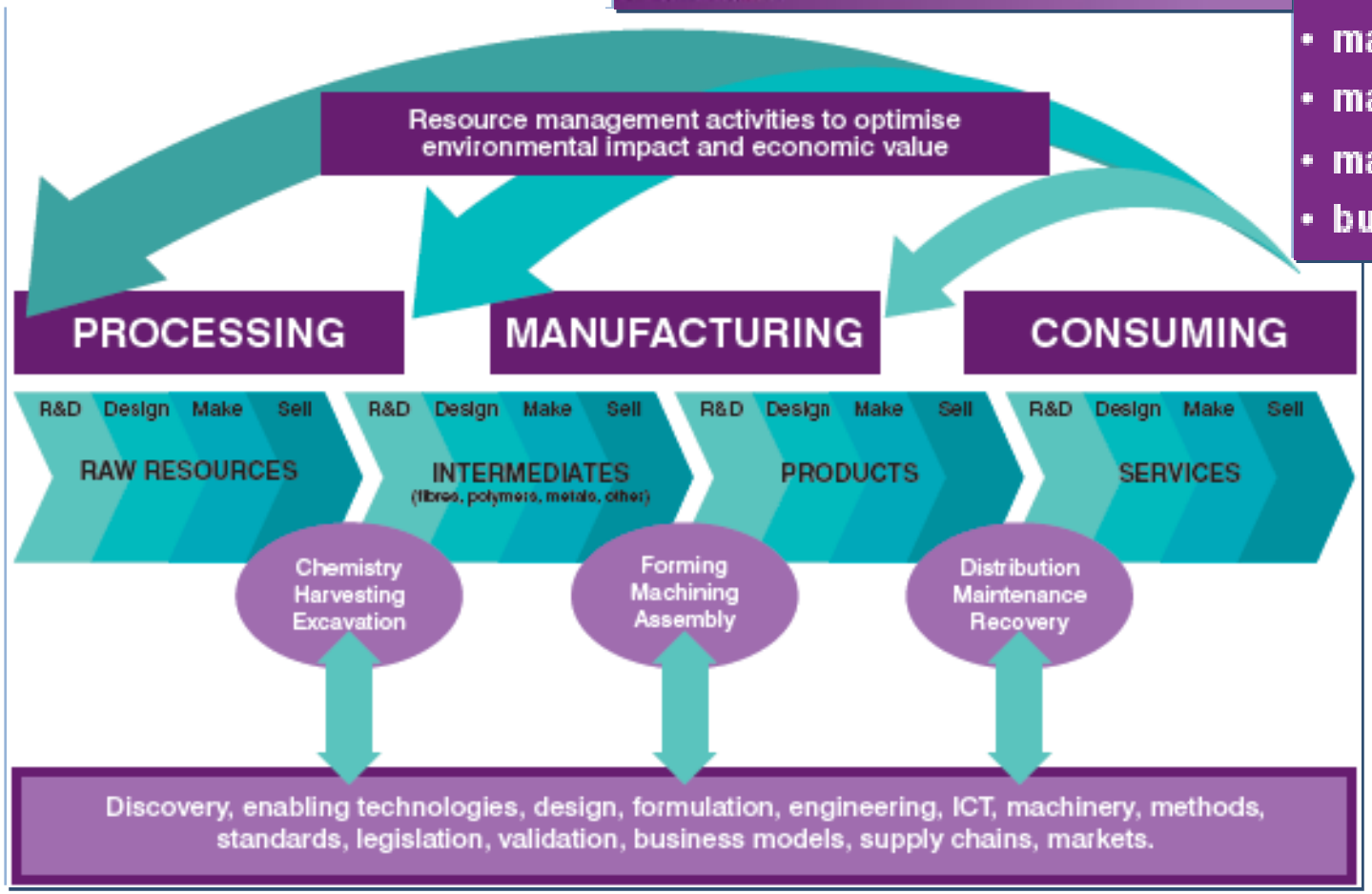
High Value Manufacturing Landscape

- R&D areas:
  - New composites
  - Light weight materials
  - Additive manufacture
  - Flexible and adaptive manufacturing
  - Customisation & small run technologies (including distributed manufacture and ‘batch size of one’)
  - Sensor technologies
  - Robotics & automation
  - micro and nano-manufacturing processes
  - end of life activities
    - recycling, re-use, renewing and re-lifing
  - surface engineering (finishing and coating processes)
  - link design and manufacturing more closely
  - integrating technologies and processes
  - bioprocessing for new/replacement
  - ICT and enabling structures

Technology Strategy Board
Driving Innovation

High Value Manufacturing Strategy

- resource efficiency
- manufacturing systems
- materials integration
- manufacturing processes
- business models.



Foresight Report

Foresight (2013). The Future of Manufacturing: A new era of opportunity and challenge for the UK ; Summary Report; The Government Office for Science, London

"Manufacturing in 2050 will look very different from today, and will be virtually unrecognisable from that of 30 years ago….as manufacturing becomes faster, more responsive to changing global markets and closer to customers…exposed to new market opportunities and more sustainable"

- Mass personalisation of low-cost products, on demand
  - "Direct customer input to design will increasingly enable companies to produce customised products"
- Distributed production
  - The production landscape will include capital intensive super factories producing complex products; reconfigurable units integrated with the fluid requirements of their supply chain partners; and local, mobile and domestic production sites for some products.
  - The factory of the future may be at the bedside, in the home, in the field, in the office and on the battlefield.
- Digitised manufacturing value chains
  - they will create new ways to bring customers into design and suppliers into complex production processes.

Manufacturers are increasingly using a wider 'value chain' to generate new and additional revenue from pre and post production activities.

Looking forwards

Current thinking from the RCUK GFS working group on 'Priority Research Questions for the UK Food System' and the KTN / FDF 'Priorities for collaborative pre-competitive research'

- How can the fat, sugar, preservative and salt content of foods be reduced while ensuring that palatability is maintained, waste is minimised, and food remains safe and does not spoil?
- How can primary food production be sustainably intensified whilst maintaining or enhancing the nutritional value of those food items?

Opportunities for future research funding were seen under three general headings of 'Production' (including safety, nutrition and sustainability), 'Manufacture' and 'Behaviour'

Global Food Security
Sustainable, healthy food for all

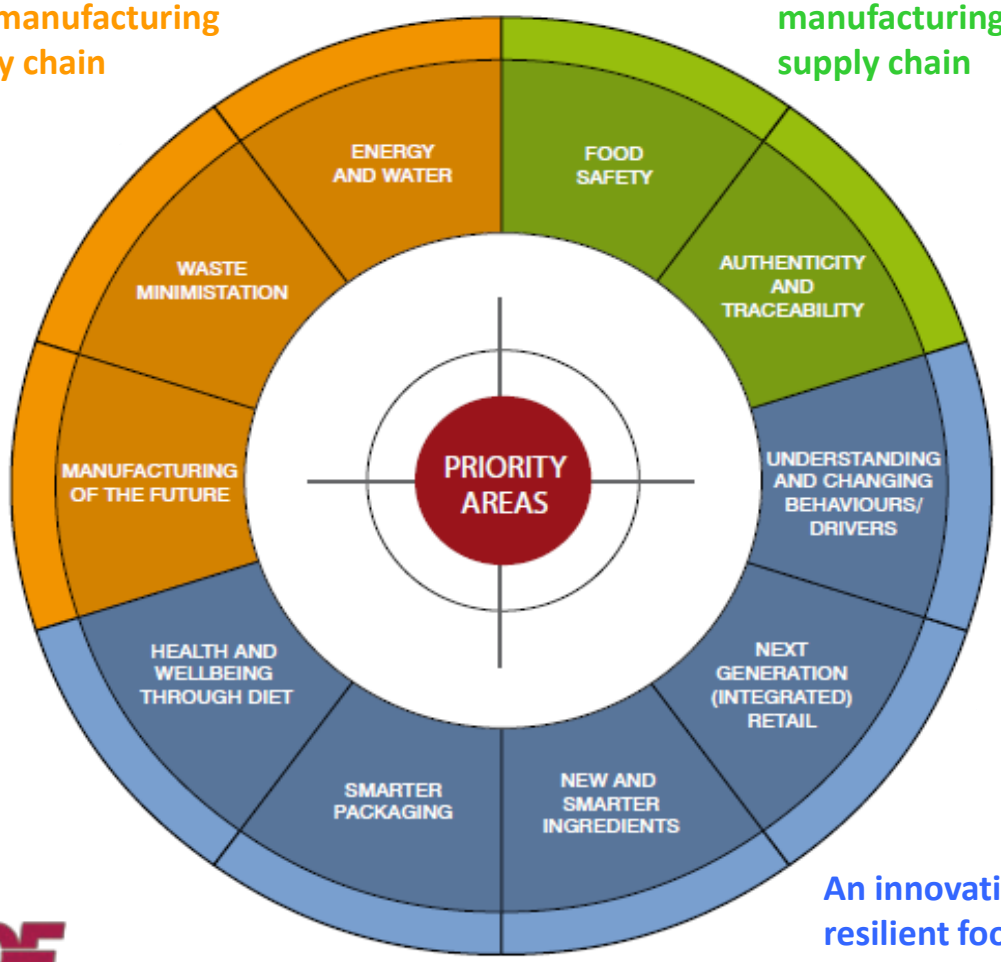
Looking forwards

The University of Nottingham
UNITED KINGDOM · CHINA · MALAYSIA

PRIORITY AREAS FOR RESEARCH TO MAINTAIN AND ENHANCE THE UK'S COMPETITIVE POSITION IN GLOBAL FOOD MANUFACTURE

A resource efficient food manufacturing supply chain

A safe, secure food manufacturing supply chain



An innovative, resilient food supply chain for the 21st century populations

Knowledge Transfer Network
Biosciences

Food and Drink Federation
Delivering Sustainable Growth

Looking forwards

- Consumer driven (future interface) – we need to identify what the consumer of the future looks like and is willing to pay for, then work backwards to see how our manufacturing processes can meet their demands
- Flexible, automated manufacturing environment
- Material and energy efficiency of our core manufacturing
- A need for Nanotechnology science, to explore the 'safe for use' agenda and also to determine efficacy of delivery mechanisms. Company nervousness in this area requires understanding of responsible use and processability, for a detailed applications use e.g. as anti-microbials (in formulation and packaging), and as potential delivery mechanisms for nutrients and tastants / aromas (next generation nutraceuticals).
- A tool kit for engineering structures to deliver tastes / nutrition, using new raw materials, which could be from different crops, with selected varieties as 'superior' raw materials of the future. This may be a redefining of the use of what is already there (pulses and grains agenda).

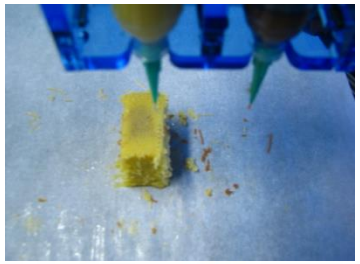
So what can we pick out from this?

- Better use of resources
  - Materials / water / energy
- Need for flexibility in manufacturing
- Portfolio of automated mass production and small scale customised production
- Products designed for efficacy

Precision manufacture

- 3D printing

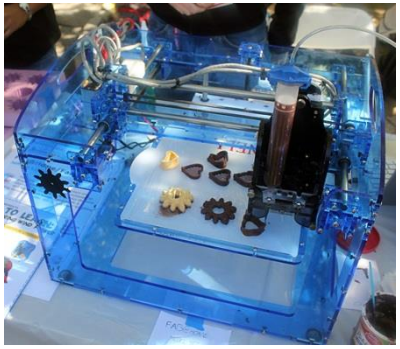
http://www.bbc.co.uk/news/technology-25647918

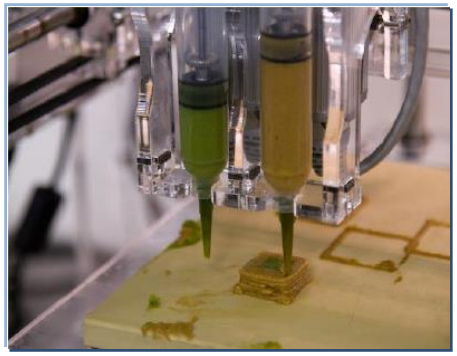


The printer is able to create sweets in designs that would be difficult to achieve using other processes

Chief executive Avi Reichental believes the smaller of the two printers could be used by restaurants and bakeries

- Solid freeform fabrication (Cornell, Massey, Birmingham)





Precision manufacture

- Additive manufacture

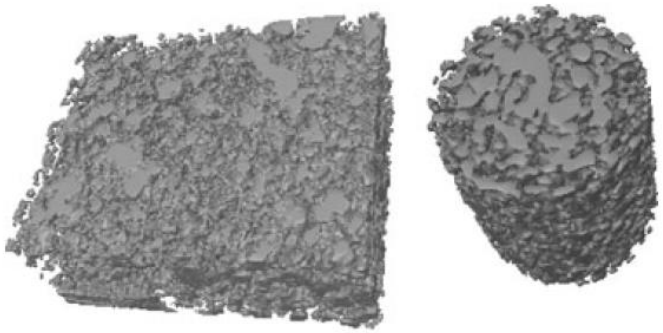
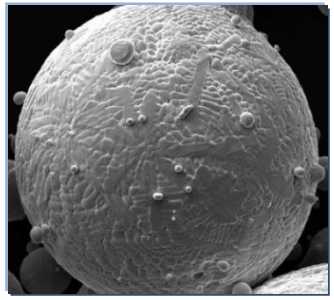


Figure 3–3-D reconstructions of (A) biscuit and (B) breadstick samples.

10mm

- HIP / Additive layer manufacturing & flash sintering



Melt extruded cellulose

- May enable a redesign of the way we make food and the materials we use to allow healthier, more nutritious offerings. SCALE WILL BE THE ISSUE

DISPOSABLE solutions
for Biomanufacturing

Industry Report

Disposable Techologies and Single Use Systems for Biomanufacturing 2014

www.disposablebiomanufacturing.com

Low energy manufacture

- Laser drilled membranes

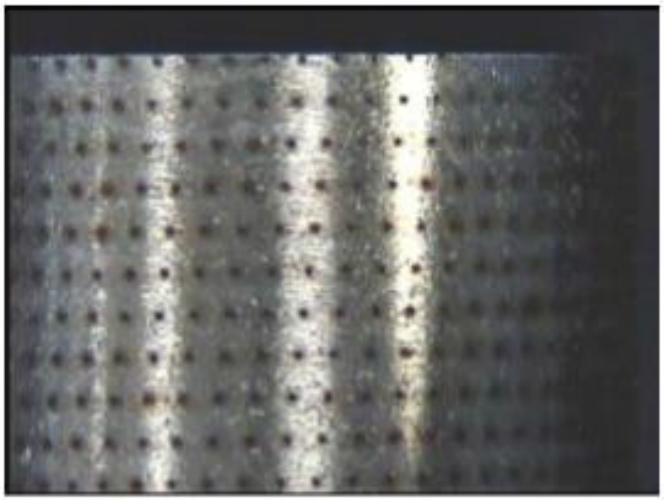
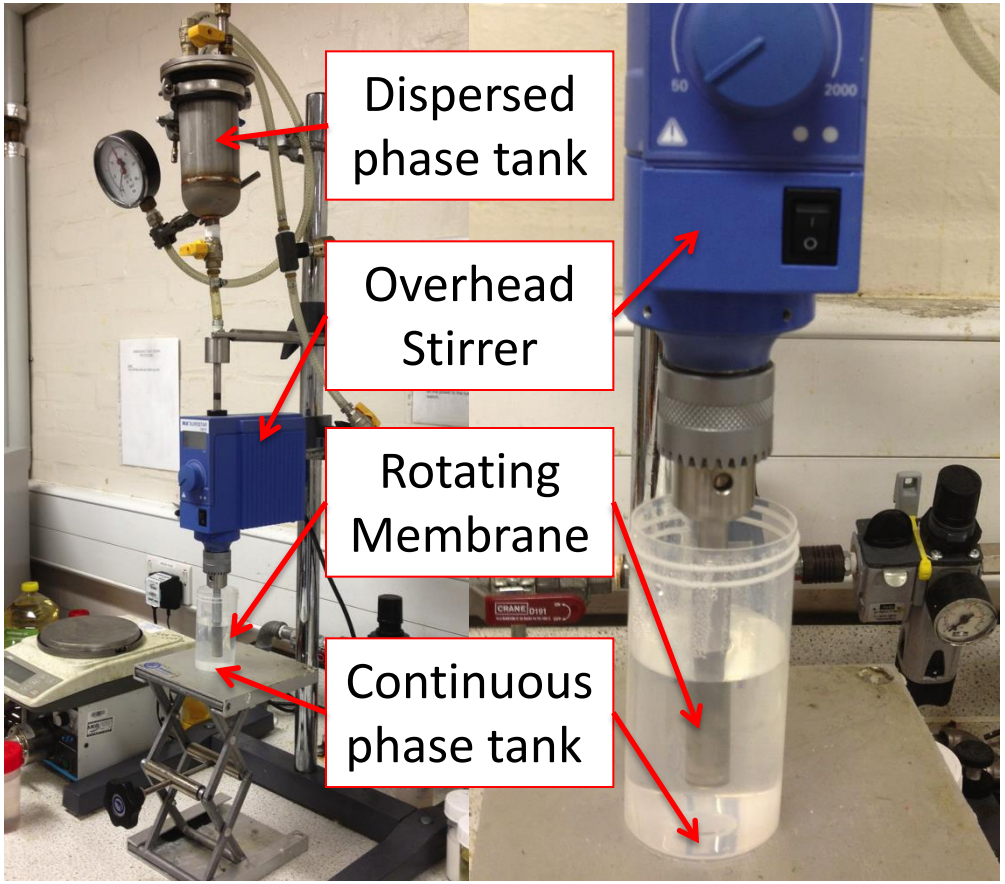


Figure 3. Detail showing staggered arrangement of holes in the array with approx hole separation of 0.5mm.



New materials

- Better utilisation of what nature provides

- Pre-processing steps?
  - Steam (explosion), microwave

EPSRC
Engineering and Physical Sciences Research Council

EPSRC Centre for Innovative Manufacture in Food

£5.6m to be spent on Research
Started 1st December 2013

Prof Tim Foster, Prof Shahin Rahimifard and Prof Ian Norton

The University of Nottingham
UNITED KINGDOM · CHINA · MALAYSIA

Biomaterials Group

Loughborough University

Centre for Sustainable Manufacturing and Recycling / Reuse Technologies: SMART

UNIVERSITY OF BIRMINGHAM

Centre for Formulation Engineering

How did we get here?

EPSRC
Engineering and Physical Sciences Research Council

2007 2009 2011 2013 2014

What is Required?

- Achieving sustainable food production
- Tailor-made foods to preference / acceptance / needs of consumers
- Entrepreneurial / innovative Industry
- Changing operating procedures
- Small Scale efficient and flexible processing
- Hygienic processing
- Ingredient functionality and security of supply
- Limited water
- Biomass refining
- Food product design and fabrication

What we will do

- Innovative manufacturing activities from 'post-farm gate to supermarket shelf', and the implications on Resource Efficiency and Sustainable Production
- Innovative materials, products and processes
- Sustainable food supply and manufacture
- Creating 38 new jobs
- Creating **THOUGHT LEADERS** of the future

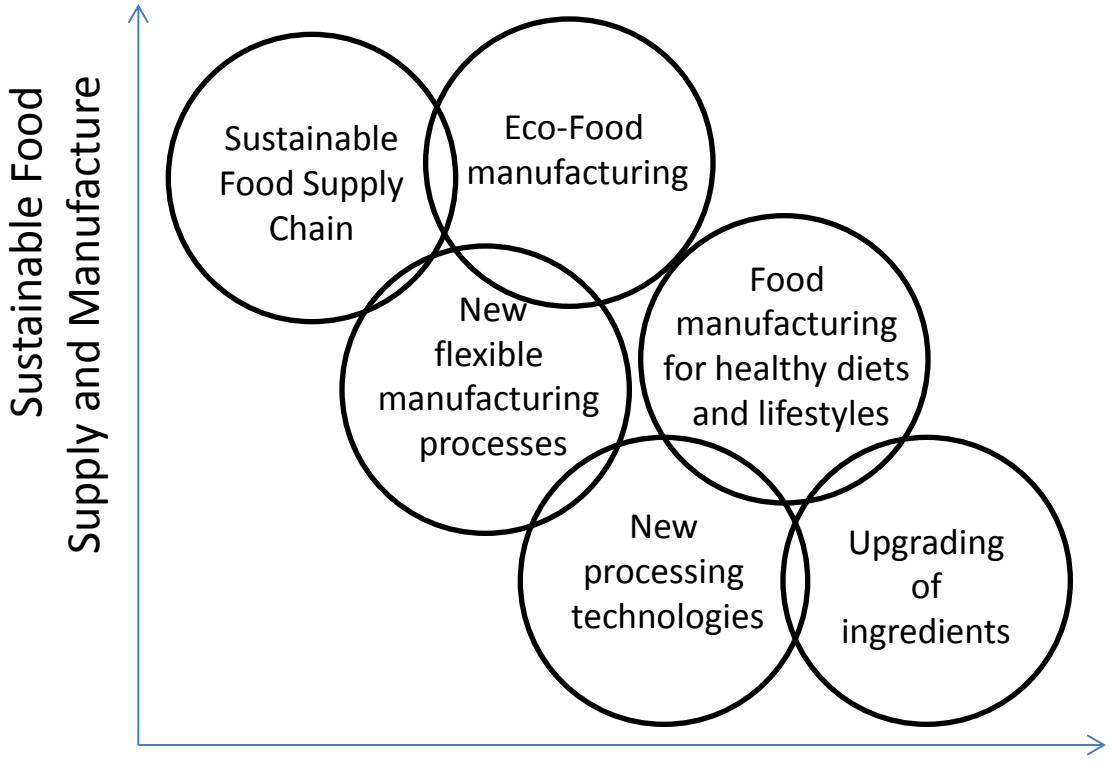
Current views

'This approach encompasses the whole life-cycle of processed foods.'

'The concept of farm to fork is too limited, and needs to be expanded to that of **from farm through digestion**.'

- Reducing our environmental impact
- Meeting growing global demand for food
- Producing more from less as pressure increases on resources
- Reformulating and creating new products to meet diet and health requirements

What is our focus ?



The two Centre Grand Challenges and their six Research Themes

Co-creating products of the future –
With ingredient and process developments

How do we align with current thinking ?

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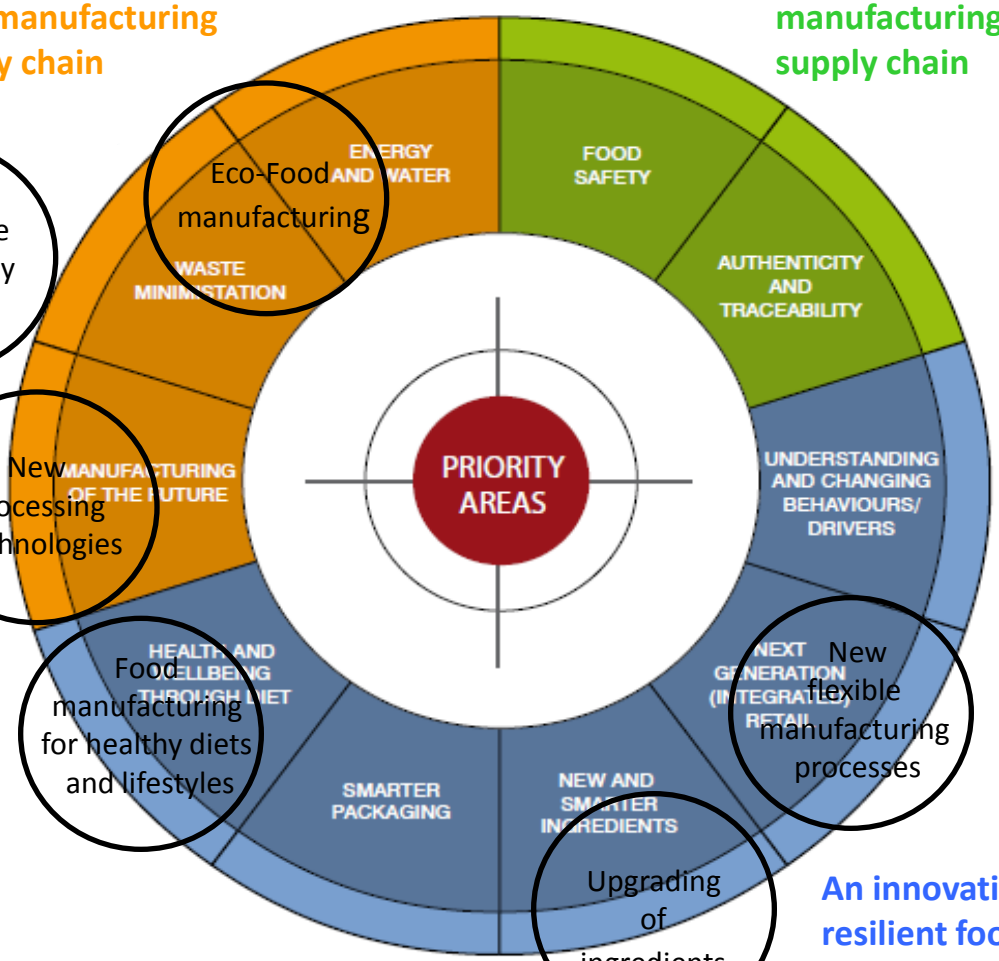


Sustainable Food Supply Chain

Eco-Food manufacturing

New processing technologies

Food manufacturing for healthy diets and lifestyles

New flexible manufacturing processes

Upgrading of ingredients

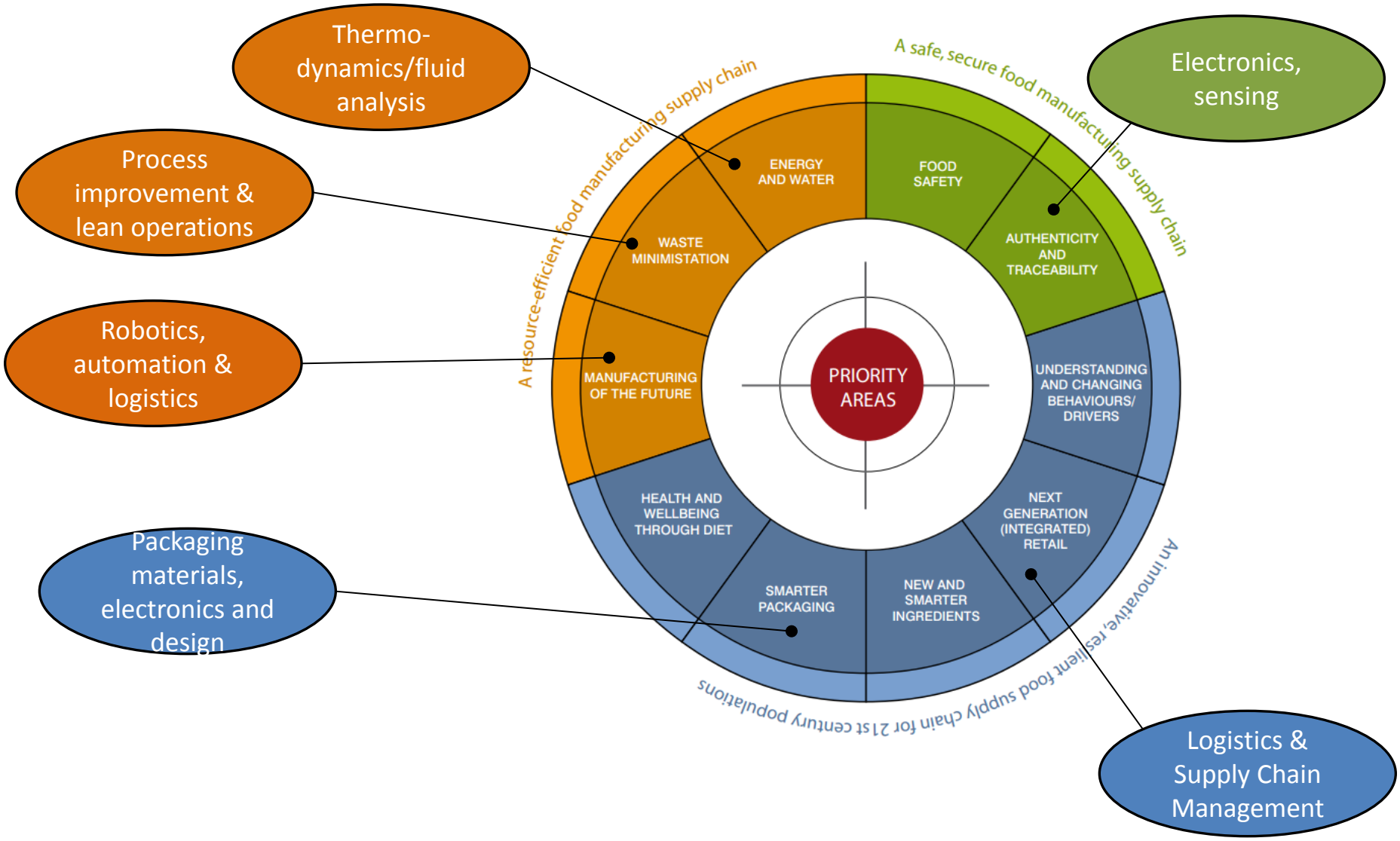
An innovative, resilient food supply chain for the 21st century populations

Sheffield Hallam University

HEFCE National Centre of Excellence for Food Engineering

Dr Martin Howarth

Sheffield Hallam University's contribution to the sector's priority areas



Other current activities (EPSRC funded)

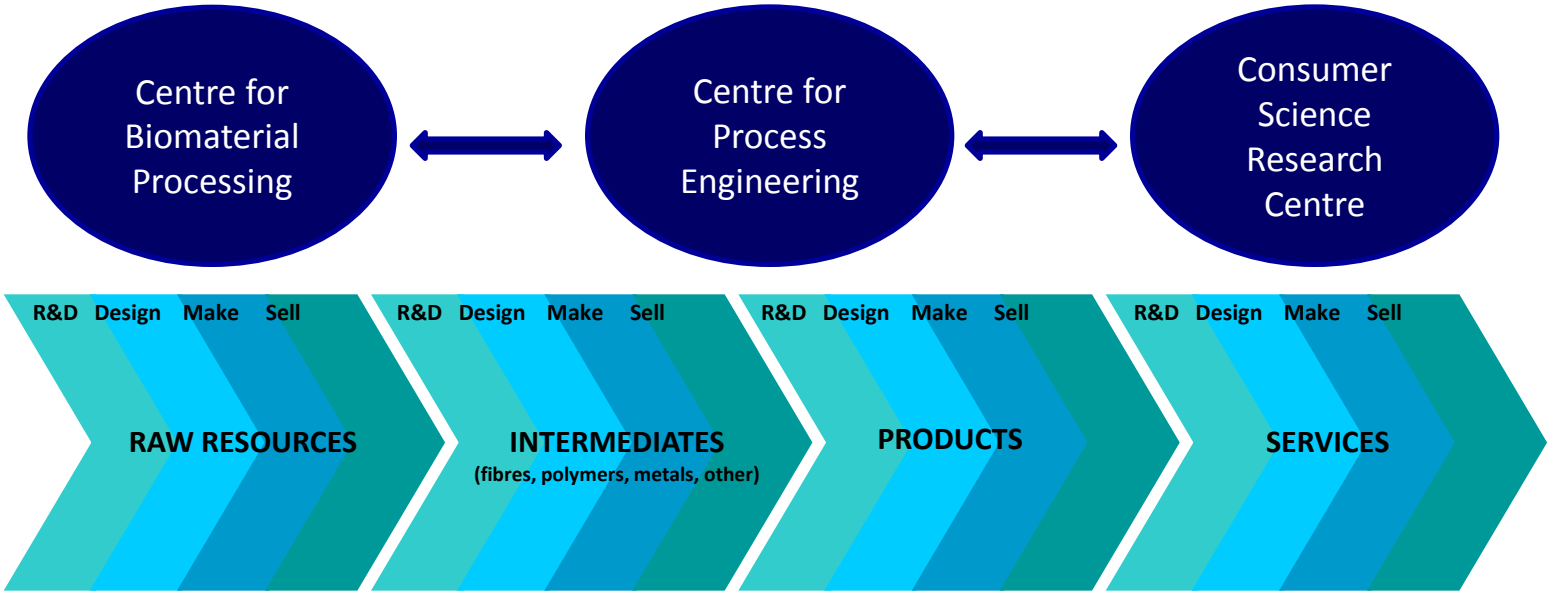
Prototyping Open Innovation Models for ICT-Enabled Manufacturing in Food and Packaging Jan 2013 £1.8m

- To design and implement mechanisms to feedback the 'Crowd's' needs and real world use, interaction and experience and translate these into design specifications of desired attributes for the food product they wish to consume, by collaborating directly with product development and manufacturing specialists.
- To develop the methodology, ICT tools and a knowledge base to convert desired attributes of food into food product and packaging specification that can be produced and delivered to the consumer.
- To develop responsive manufacturing models and an ICT toolset to enable fast response to new and emerging food products by flexibly aligning and coordinating manufacturing resource to such needs.

CENTRE FOR SUSTAINABLE ENERGY USE IN FOOD CHAINS £5.7m

- Simulation of energy and resource flows in the food chain, from farm-gate to plate.
- Investigation of approaches and technologies for the reduction of energy use at all stages of the chain.
- Identification of optimal ways of interaction between the food chain and the UK energy supply system.

An Integrated Approach



Thank you for your attention.