

Position  
Statement on  
Food Security  
and Safety

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Executive summary



## Executive summary – key conclusions for policy-makers

Microbiological research has been and continues to be central to meeting the global challenges of food security and food safety, defined by the Food and Agriculture Organization [1] as ‘*when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life*’.

With the world’s population predicted to rise from its current 7 billion to 9 billion by 2050, producing enough food to feed this expanding population has been recognized as one of the greatest challenges facing mankind. In 2011, a major 2-year study from the UK Government Office for Science ‘Foresight’ programme *The Future of Food and Farming* [2] was published, outlining the emerging issues and challenges to global food security and safety. A number of action plans to meet this challenge have been published by the relevant global agencies, including UK government departments, research councils, the Royal Society and others [3, 4, 5, 6, 7].

The Society for General Microbiology (SGM) in partnership with other leading microbiology and microbiology-related organizations, the Society for Applied Microbiology, the British Mycological Society and the British Society for Plant Pathology, is concerned that the role of microbiology in meeting these challenges is poorly understood and under-represented at a time when funding for universities and institutes has been cut, leading to a shortage of expertise in many important microbiology disciplines across the UK [6].

Food security is not just about increasing food productivity; it is also about wasting less. Furthermore, supplying safe, nutritious foods must be achieved in a sustainable manner with minimal impact on the environment and animal welfare. Meeting the challenges is exacerbated by a number of key drivers and constraints, including climate change, energy usage, mineral and water availability and population dynamics, and to be sustainable must occur within the ‘*safe operating space for humanity*’ identified by Rockström *et al.* [8].

Microbes (bacteria, fungi, viruses, protozoa, algae and archaea) and their activities are involved at every step of the food chain. Understanding the role of microbes at all steps in the process of plant and animal production, soil and water management, and harvesting, storage and processing of agricultural products is necessary. Now and in the future, microbiological research and development will play a profoundly important role in sustaining and improving food production, food safety, and environmental quality while reducing waste.

Critically, investment in microbiological research and development to tackle food security and safety will have measurable socio-economic benefits. For example, for every 1% reduction in crop pests and diseases it has been estimated that an extra 25 million people could be fed [9], and for each 1% reduction in the overall incidence of UK food-borne disease it has been estimated that there would be around 10,000 fewer cases each year; this 1% represents an economic saving of around £20 million [15].

History records that microbiological research has delivered major advances in food security and safety. Important milestones include:

- Identification and application of safe processes for food preservation, such as canning and pasteurization, and understanding the biology of pathogenic and spoilage microbes to reduce their transmission in the food chain, leading to developments of safer foods with a longer shelf life.
- Exploiting antimicrobial substances produced by naturally occurring microbes as weapons against plant and animal pathogens.
- Vaccine development to improve the health of livestock and reduce transmission of animal pathogens to humans.
- Producing novel food products, including probiotics and nutritionally enhanced food through fermentation.
- Exploiting microbial processes to manage or reduce waste.

It needs to be recognized that there are key overarching factors which impact on microbiological activity, including:

- Microbes do not respect international boundaries and consequently food-borne pathogens, and also animal and plant diseases, such as foot-and-mouth disease, classical swine fever, coffee leaf rust and soybean rust, can be spread rapidly worldwide via trade, travel or arthropod vectors, depending on the pathogen, to new geographical areas. Moreover some microbes move between animals and humans, introducing diseases and resistances to antibiotics.
- In their natural habitat, microbes live in diverse, complex, interdependent communities, the ecology of which must be fully understood if we are to eradicate disease and exploit the beneficial role that microbes play in achieving food security.
- Many microbes have the capacity to evolve rapidly to become better suited to *their* environment, not necessarily to our benefit, thereby changing their behaviour and meaning that continual vigilance is required. Such evolution can allow microbes to escape control by drugs or vaccines, meaning that diseases that were once considered under control may re-emerge.

Nine research themes have been identified where the role of microbiological research is crucial to help meet the challenges of ensuing global food security and safety.

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## Research themes

Within this Executive Summary, just two areas of necessary research are identified for each theme. The full report provides a more detailed set.

### 1. Soil health and nutrient cycling

The soil microbial community is largely uncharacterized, but is responsible for decomposition of organic material and biogeochemical cycling to provide plant nutrients, capture and release of essential minerals, and maintenance of soil structure. Microbial respiration of nitrate is estimated to account for as much as one-third of the loss of fertilizer or other nitrogen sources from soil-containing plants [11]. Further research into the soil community and role in nutrient cycling will allow optimization of nutrient yield, for example research to:

- Understand the role of microbes in nutrient cycling, particularly phosphate, nitrogen and micronutrient metals.
- Determine the effect of external factors on soil microbial communities and their functions, such as decomposition and nutrient cycling.

### 2. Plant–microbe dynamics

Microbial interactions with plants can be beneficial (for example nitrogen fixation or mineral uptake in root systems), parasitic or pathogenic. Microbes can switch between beneficial, parasitic and pathogenic stages during their life-cycles; understanding these change triggers is essential for controlling pathogens and enhancing beneficial interactions to maximize crop yields in a sustainable way. Research is needed to:

- Enhance beneficial (for example mycorrhizal, rhizobial or endophyte) plant–microbe rhizosphere (volume of soil around the plant roots) and phyllosphere (leaf surface habitat for microbes) interactions to enhance nutrient uptake and stress tolerance.
- Understand and exploit the triggers that change microbes between beneficial, parasitic and pathogenic stages of their life-cycles as a means to identify durable crop resistance and better target crop protection.

### 3. Crop pathogens

Pests and diseases can considerably decrease crop production with current losses, estimated to be more than £150bn worldwide [12], contributing to global food insecurity. There are opportunities to exploit new methods and models to decrease disease-induced crop losses. Research is needed to:

- Identify crop resistance against pathogens that is durable through exploitation of new crop and pathogen genomic data, and new understanding of factors affecting severity of epidemics.
- Guide government/industry strategies by exploiting new models to predict impacts of changes in climate and agricultural practices on severity of crop diseases.

#### 4. Gut microbiology in farm animals

The complex population of micro-organisms in the gut of farm animals plays an important role in the nutrition and health of the animal. In sheep and cattle, microbes are responsible for conversion of plant material into energy and protein to support meat and milk production, but also production of methane, a potent greenhouse gas. In pigs and poultry the gut microbes play a key role in digestive efficiency and in preventing the passage of pathogens. Research is needed to:

- Develop novel methods to modify the gut microbial population in beneficial ways, for example to improve energy retention from the diet and to decrease the production of greenhouse gases from farmed livestock.
- Understand how indigenous microflora in the gut protects against invading microbes.

#### 5. Animal pathogens

Infectious diseases of food-producing animals result in reduced efficiency or significant losses in food production from animals and adversely affect animal welfare and trade. With nearly 700 million of the world's poorest people relying on farming animals for their survival [13], effective control of animal pathogens is crucial not only for safeguarding and securing national and international food supplies, but also for alleviating rural poverty in developing countries. Research is needed to:

- Develop novel and improved rapid diagnostic tests, including simple on-farm tests, in order to detect outbreaks early enough to effect containment (c.f. 2001 UK foot-and-mouth disease outbreak).
- Develop effective control measures, such as new antimicrobial compounds and novel or improved vaccines that induce long-lived immunity and/or which protect against multiple strains of the same pathogen.

#### 6. Food spoilage

Food spoilage may be defined as any change that renders food unfit or unsafe for human consumption. Microbiological spoilage is a significant problem with respect to the shelf life of raw and processed foods (meat, fish and vegetable products) and is a key contributor to food waste. Future food security will necessitate that less food is wasted. Research into optimal storage and transport conditions, methods of food preservation and reduction in microbial contaminants will contribute significantly to the amount of food available, particularly in the developing world. Research is needed to:

- Understand the microbial ecology of pre- and post-harvest produce, and how these microbial populations can affect shelf life and food quality.
- Develop rapid diagnostics to allow for correct species and strain identification from within mixed microbial communities and understand the food source attribution of microbes.

## 7. Food safety and human diseases

Sustainable production of safe and nutritious food requires improvements in food safety. Of 335 emerging infectious diseases over the last 70 years, 60% have been acquired through animals (note that 60% relates to all zoonoses and not just food-borne ones) [14]; intensive agriculture increases opportunities for evolution and spread of harmful microbes. Food-borne illness is a global burden. In the UK, it is estimated that about 1 million people suffer a food-borne illness of which 20,000 receive hospital treatment, and there are over 500 deaths. This cost to the UK economy in 2009 was about £2bn [15]. Research is required to mitigate this:

- To better understand the microbes, their hosts, environmental factors and the interactions between them that result in transmission of pathogens in the food chain and subsequently to food-borne disease.
- To develop strategies that reduce transmission throughout the food chain, infection and disease using appropriate research models, and to predict the zoonotic and epidemic potential of microbes found in animals by exploiting state-of-the-art technologies.

## 8. Waste reduction and management

More than half of the food grown is discarded before or after it reaches consumers and over one-third of landfill waste in the UK comes from the food sector. Such landfill releases greenhouse gases, particularly methane. The core microbiological challenges of waste management concern optimization and matching of microbial processes to specific waste streams. In particular, research into controlled anaerobic digestion is required to understand this process and convert waste into usable energy and fertilizer. For example, research is needed to:

- Understand how the microbial community in anaerobic digesters can be optimized.
- Improve production of cell-wall-degrading enzymes from microbial sources for the commercial breakdown of plant structures.

## 9. Novel methods

The vast majority of micro-organisms – whether beneficial, harmful or neither – remain to be discovered. Even the presence or absence of organisms we know may be difficult to determine. Research needs to focus on new identification techniques and accurate data acquisition to unravel the complexity of microbial communities involved in the production and utilization of food and for increased tracing of microbes through the food chain. For example, research is needed to:

- Develop data management systems that are capable of collecting, storing, analysing and communicating data.
- Develop methods to study unculturable microbes, which are becoming increasingly implicated in disease and environmental functions such as nutrient cycling especially in soil, and to trace pathogenic and spoilage microbes through the food chain.

The SGM recognizes that any proposed solutions to the challenges of food security and safety will require multidisciplinary, multinational teams to effectively meet the global challenges of our future food supply. However, to deliver potential solutions to this global issue, funds need to be committed to:

- Support microbiology research programmes and to procure the necessary resources required to deliver the proposed research.
- Support the training and development of skilled microbiologists.
- Provide world-class research facilities, including those needed to study microbes in the animal, crop or environmental systems where they act rather than surrogate laboratory-based models.