Science Overview

Wayne Powell & John R. Hillman

The scientific reports from the four Heads of Division comprehensively cover the main aspects of the Institute's research activities. This article deals with the more strategic point of how the SCRI scientific portfolio meets the needs of our public- and private-sector sponsors, and society generally. 'How does our science make a difference'? To address this issue, we need not only to examine our scientific and technological competencies, but also to re-calibrate our thinking to take into account fundamental changes in the agricultural industry. Globally, commodity prices are under pressure. There has been a prolonged period of buoyant agricultural production unaffected by massive weather perturbations and by depradations of pests and diseases. Food has never been so plentiful for the bulk of the world's population. In Europe, reforms to the Common Agricultural Policy, particularly those leading to an erosion of production subsidies with more emphasis being placed on environmentally benign production systems, will herald a new era of innovation and opportunity for those organisations with the intellectual agility, managerial flexibility and competencies to respond to the new challenges confronting agriculture in the 21st century. Growing populations will pose new challenges for agricultural productivity, quality and land use efficiency. Our research perspective must, however, also consider the impact of 'society on science' as a major political and economic driver which is shaping government and EU agricultural and environmental policy. This means that scientific and technological opportunities cannot be considered in isolation from societal and political factors. Today, the role of the consumer in democratic societies is paramount, with much more emphasis being placed on safety, quality, authenticity and traceability of our food and industrial feedstocks. Some of the challenges and opportunities facing us are summarised in Figure 1. It is against this background that I wish to consider how SCRI can adapt to the changing face of agriculture, exploit its strong science base, and contribute to the future success of the agricultural and related bio-industries?

Clearly, our research needs to take into account the impact and influence of shifts in economic, political and environmental factors, but we must also be in a position to shape and influence policy by providing new and innovative solutions through the generation of fresh scientific ideas, concepts, technology, products and processes. Scientific innovation and discovery will be the main drivers for broadening the end-user relevance of our research. In parallel with enhancing our strong science base and maintaining an international perspective, we need constantly to con-

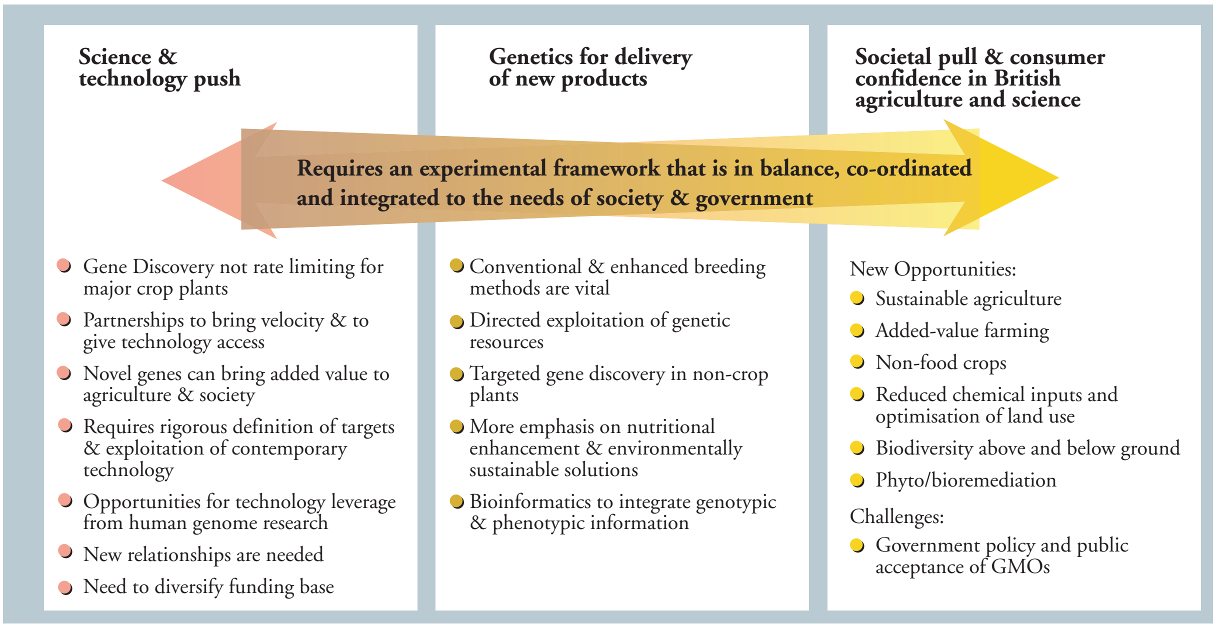

Figure 1 Opportunities & Challenges: getting the balance right.

nect our research to the food and product supply chain so that we can identify research opportunities and solve problems at multiple points along it. A critical factor will be the deployment of information or knowledge management systems that will allow us to make connections to the various groups contributing to this supply chain. The loss of subsidies is also likely to promote a wider range of farming systems, with more emphasis on added-value farming that utilises natural resources in an environmentally sustainable manner. Some, if not all, sectors of the agricultural industry will need to be more competitive globally and this will require access to, and the introduction of, new technology in a responsible manner. At SCRI, we have access to unrivalled genetic resources and possess the skills and competencies to move from genes to products *via* plant breeding and/or biotechnological routes. Such technology platforms are vital for the delivery of new products from traditional crops for the feed, food, drink and non-food markets. In addition, these skills will be essential for the creation of new niche market opportunities. Success in this arena is very dependent on understanding market needs and translating these needs into breeding and research goals. Under these circumstances, a different strategic overview is needed that recognises the need for calculated scientific risk-taking and exhibits flexibility and adaptability in re-defining our research priorities to reflect changes in political, societal and market forces, and priorities.

From a research perspective, we must continue to embrace genomics and post-genomics technologies together with computational biology to ensure that our research is internationally competitive and is positioned to bring new options and opportunities to agriculture and the bio-industries. The recent completion of the genome sequences of a number of bacterial species and several eukaryotes, including one plant species (*Arabidopsis thaliana*), has profoundly affected the way in which we select and answer questions in biology. The availability of genome sequences opens up a vast range of new scientific opportunities. To capture these, we need to: i) alter the ways in which biological problems are approached; ii) attain a balance between laboratory-based research programmes and computational biology; and, iii) be prepared to change the emphasis of research activity to ensure that new scientific discoveries can be translated into viable new options for agriculture.

Based on these needs, the Institute has recently re-prioritised and consolidated its research into nine programmes that are organized around three themes: Understanding of Basic Mechanisms & Processes; Genes to Products; and, Management of Genes and Organisms in the Environment. Care has been taken to align research programmes to the needs of end-use sectors as identified by the SEERAD strategy document (1999 – 2003), as shown in Table 1.

A major priority for SCRI is to ensure knowledge transfer and exploitation of results emerging from our scientific research to the end-user communities. This is not uni-directional, however, and our research benefits from interactions with the end-user communities

	Sustainable Agriculture	Environment & Natural Heritage	Nutrition & Human Health	Food & Bioindustries
Soil & Environmental Sciences	P 6 P 7 P 8	P 3 P 5 P 6 P 7 P 8		P 6
Plant Science	P 1 P 3 P 5 P 6 P 8	P 5 P 6	P 1 P 2 P 4 P 5	P 1 P 2 P 4 P 5

P1: Gene expression, manipulation & transgenics
P2: Cell-to-cell communication
P3: Host-pathogen interactions
P4: Quality, health & nutrition
P5: Genome dynamics
P6: Ecosystem management & biotechnology
P7: Ecological plant interactions at the plant: soil interface
P8: Plant-parasite co-evolution
P9: Computational biology - cross cutting programme and relevant to all activities

Table 1 Relationship of SCRI's research programmes to science and end-user domains identified by SEERAD strategy document (1999-2003).

Themes	Research Thrust	Relevance, added-value and synergy
1. Understanding of Basic Mechanisms & Processes	• Functional genomics to validate gene-to-phenotype relationships. • Mechanisms of gene silencing/disruption. • Cell-to-cell communication & long distance transport. • Protein/protein interactions and signalling processes. • Comparative microbial genomics. • Quantification and localisation of global gene expression. • Diagnostics.	• Research that underpins gene expression, function, stability and transfer which are crucial for the development of efficient and safe bio-based technologies. • Create generic technology platforms for delivery of therapeutics and high-value biopharmaceutical products in plants. • Core competencies and skills aligned to enhance synergy in the post-genomics era. • Resistance genes for deployment in sustainable agriculture.
2. Genes to Products	• Application of large-scale and targeted gene discovery and profiling approaches to explore & exploit functional diversity in the delivery of new and improved crops. • Application of genomics technologies to plant breeding. • Comprehensive diversity studies to identify haplotype gene content. • Connecting DNA sequence polymorphisms to heritable phenotypic differences with a strong focus on pre-existing, natural variation. • Primary targets to include product quality and nutritional value.	• Focus on genomes as a source of genes to provide options for novel products that can be exploited by both breeders and biotechnologists. • Provide the resources and technology required to clone and manipulate genes controlling complex phenotypes. • Devise new breeding strategies that embrace and exploit the tools of contemporary genetics. • Improved understanding, characterisation and exploitation of plant genetic resources. • Combined genomic, genetic, biochemical, phytochemical and breeding expertise for the delivery of next generation crops and products for the benefit of consumers and other end-user communities.
3. Management of Genes & Organisms in the Environment	• A universal, individual-based approach linking plant traits to population characteristics. • Effects of population (genetic) diversity on ecological resilience. • Interdependence over space and evolutionary time of plants, herbivores and parasites. • Understanding of plant-parasite interactions and response to the environment. • Disease epidemiology.	• Research underpinning environmentally sustainable production systems, with particular emphasis on conserving and utilising biodiversity and protection of soils. • Ecological management of genetically modified crops in the environment. • Integration of research activities from molecules through to genomes and populations and their biological interactions in the environment. • Integrated pathogen/pest management.

Table 2 Conceptual basis for the development of themes and relevance to SCRI's science strategy.

by ensuring that markets are correctly identified and translated into viable research targets.

The organisation and integration of research programmes into Themes (Table 2) reflects our need to change in response to technological advances and to attain a balance between discovery science, as illustrated by genome sequencing projects, and traditional hypotheses-driven research groups. Changes are also required to ensure that our research is connected to the food supply chain and recognises the need to move beyond the simple 'farm gate to the dinner plate'concept. Table 2 summarises the main research foci of each theme together with relevance, added value and our vision to broaden the end-use relevance of our research to include the production of high-value biopharmaceutical products.

The timely delivery of these research goals is dependent on investment of resources. Fortunately, our successful bid for supplements to our grant-in-aid, the so-called 'outer core' component, will reinforce strongly our capability and competency in selected areas in each of the three Themes. The ways in which the outer-core programmes are integrated with our core activities are designed to 'use modern biotechnological and information science tools to create plants, especially crops, that are capable of delivering added-value products in an environmentally sustainable manner'. These goals also contribute to the creation and development of cross-disciplinary teams. Our future success is also dependent on access to cutting-edge technology. During the past year, we have identified two priority areas for capital equipment investment: large scale genotyping/sequencing and metabolic profiling and proteomics. The purchase of an ABI 3700 system, together with a PSQ 96 Pyrosequencing system, provides state-of-the-art technology for gene discovery and single nucleotide polymorphism (SNP) detection. Two new mass spectrometers (ThermoQuest LCQ-DECA and ThermoQuest TEMPUS-TOF) have also been purchased to increase substantially our capabilities and sample turnover in both high-throughput metabolic profiling and proteomics. A Q-Bot (Genetix) robotics system for colony picking and arraying technology has also been purchased. The picking system is the fastest on the market, with a capacity of up to 3,500 picks per hour. The Q-Bot has two arraying facilities, gridding on membranes to a maximum density of 23k clones per 22cm filter, and microarraying onto glass slides to 14k spots per slide. This is only the third Q-Bot to be installed in the UK and the first in Scotland.

A vital aspect of our future science strategy is the need to develop partnerships to bring velocity and, in some cases, to allow technology access. A good example of this is provided by our relationship with Large Scale Biology, USA. Outer-core funding is designed to extend and broaden our relationship with LSB, particularly in the area of viral vector development in barley and cereal functional genomics. The production of recombinant proteins in plants *via* viral vectors represents an opportunity to create biopharmaceuticals relevant to clinical medicine. Part of our strategic intent, therefore, is to explore with LSB research and commercialisation partnerships, methods that will allow delivery of SCRI's science and technology to a wider range of end-users.

The recently formed strategic alliance with the Waite Institute, Adelaide, Australia also provides an example of partnerships between organisations with complementary expertise and is designed to make our research more competitive globally. In this case, we are exploring options for joint funding from various agencies to develop new approaches to the localisation of quantitative traits based on association mapping. These examples of strategic alliances, together with our role as co-ordinating centre for the International Triticeae Mapping Initiative, reflect the needs of modern biology where new relationships are needed to accelerate and integrate our R&D effectiveness.

The interface between research and post-graduate training is a traditional strength of the Institute that merits renewed investment. Post-graduate students and visiting scientists are a valued and integral part of the academic life of SCRI. Generations of students and visitors have benefited from SCRI's unrivalled facilities, resources and competencies of our staff. Part of our vision, therefore, is to establish a recognised post-graduate school at the Institute that actively markets our unique range of facilities and expertise. These developments reflect our commitment to train talented postgraduates and to nurture our relationships with universities in the UK and overseas to ensure that SCRI plays a pivotal role in the generation of future scientific leaders.

In conclusion, our future success will be built around four inter-related elements: innovation, internationally competitive research, partnerships to develop new opportunities and attract inward investments, and the need to realign our research priorities to deliver added-value options for agriculture and the related bio-industries. We must continue to meet successfully our demanding performance indicators and unrivalled value-for-money research productivity. Finally, we must recognise that information technologies are transforming our society and we are in the midst of an information revolution. Our future will be dependent on enhancing our visibility and using many forms of communication beyond conventionally printed scientific articles to reinforce our identity and purpose.