

GLOBAL SCIENCE LASTING BENEFITS



ROTHAMSTED
RESEARCH

2017

2022

CONTENTS

- 01 FOREWORD**
From gene to field...
fresh, global, lasting
- 02 OUR VISION**
Excellence and integrity,
collaboration and innovation
- 04 THE CONTEXT**
Economic, social and
environmental drivers
- 10 OUR SCIENCE**
Superior crops, securing
productivity, future foods
- 22 FRESH THINKING**
Lean Science to innovate more
dynamically and collaboratively
- 24 ENGAGING WITH US**
Proactive and creative
roots to partnerships
- 26 OUR BUSINESS**
Supportive and sustainable,
diverse and growing
- 28 ABOUT ROTHAMSTED**
Profile, history and
current structure

FOREWORD

FROM GENE TO FIELD... FRESH, GLOBAL, LASTING

Working from gene to field is what
Rothamsted Research is all about.

And we've been at it for more than 170 years, much longer than any other agricultural research institute in the world. Our founders, in 1843, were the pioneers of modern agriculture, and we are known for our imaginative science and collaborative influence on fresh thinking and farming practices.

Our vision is to build on these positive developments to deliver research and innovation that address strategic priorities, nationally and internationally.

Rothamsted plays a leading role in meeting the opportunities and challenges facing agriculture around the world, and towards achieving the Sustainable Development Goals of the United Nations.

In developing our strategy, we aimed to capture the trends and diverse views on the future; to identify

big challenges; to understand the immediate and future needs of our key clients and beneficiaries; to assess our strengths and impact; and to review our own science and culture.

The result is a strategic framework for delivering, with our partners in the public and private sectors, economically and environmentally resilient farming solutions for the sustainable intensification of arable and grassland-livestock systems.

At its heart, our long-term strategy recognises the need to bring together fresh thinking, global science and lasting innovation to secure food production, to protect the environment and to benefit farmers and communities worldwide.

We look forward to being your partner in this exciting adventure.



**ACHIM
DOBERMANN**
Director and Chief Executive

OUR VISION

OUR STORY, OUR VALUES, OUR PURPOSE

Our core values, and how we define them, endorse our commitment to productive and sustainable agriculture.

Rothamsted is a world-leading research centre with a proud history of ground-breaking discoveries in agricultural science since its founding in 1843.

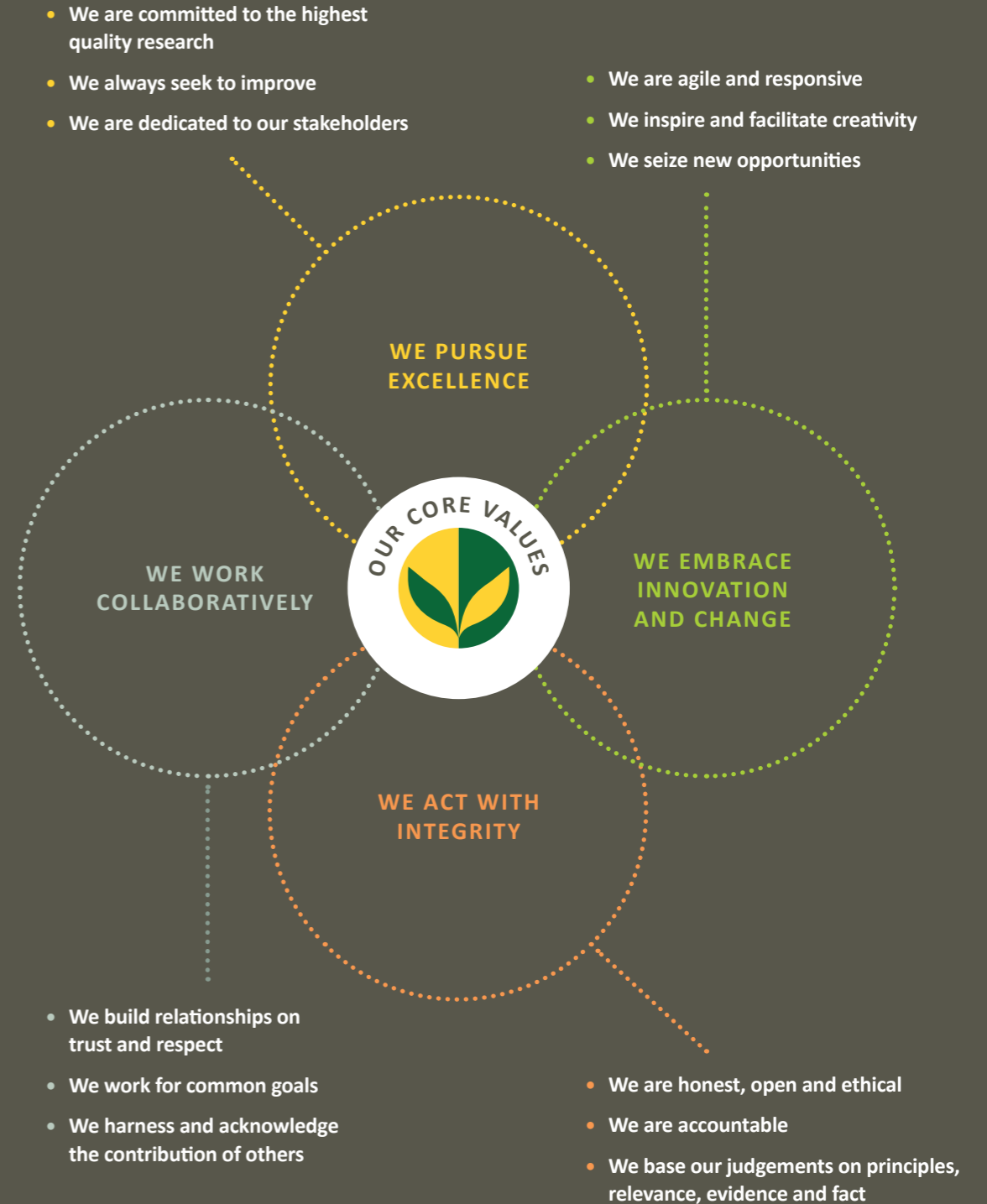
In terms of its economic contribution, the cumulative impact of our work in the UK now exceeds £3000 million a year (*Rothamsted Research and the Value of Excellence. Séan Rickard, 2015*).

We view science as a continuum, from blue skies to green fields, and strategic research as the tool to confront complex problems. We combine both, supported by unique capabilities and interdisciplinary teams, strengthened by partnerships.

Such a systems approach is the only way to achieve highly productive but environmentally-benign farming and food innovations.

PURPOSE STATEMENT

We bring together fresh thinking and global science for lasting benefits worldwide.





“Science and innovation can secure food production, protect the environment and benefit farmers and communities worldwide”

THE CONTEXT

FRESH THINKING

Five drivers of change present significant opportunities under our new strategy.

FOOD SECURITY AND SUSTAINABLE DEVELOPMENT

By 2050, changing diets and a world population topping 9 billion will drive a 60% increase in demand for agricultural outputs relative to 2010 (when the population was under 7 billion). Meeting this demand requires minimal conversion of natural ecosystems to farmland.

INTERCONNECTED GLOBAL RISKS

Rising income and wealth disparity, increasing polarisation of societies, intensifying environmental dangers, and a society that finds it difficult to keep pace with technological change are among the key risks of a global economy doubling in size every generation.

KNOWLEDGE AND TECHNOLOGY INTEGRATION

More integrated, holistic approaches to crop and livestock farming will be required. Leading agricultural businesses are already moving in that direction, looking for innovations at the interface of genetics, biotechnology, chemistry, soils, agronomy, engineering and computing.

MORE NUTRITIOUS, HEALTHIER DIETS

Cardiovascular and other non-communicable diseases related to unhealthy diets, such as obesity and type-2 diabetes, are becoming the number one health risk worldwide, even in many developing countries. At the same time, more consumers are focusing on healthier, natural foods.

BIOECONOMY INNOVATIONS

Agriculture could be a source of innovations for the wider bioeconomy; like biofuels, new industrial uses for crops could add more value to farming. A leaner, more entrepreneurial culture could innovate faster by tapping research expertise in other areas, from pharmaceutical drugs to industrial lubricants.

THE CONTEXT

GLOBAL SCIENCE

We collaborate with organisations across the world in diverse ways, extending the scope of our science and achieving greater impact on global agriculture.

EDMONTON, CANADA

The Global Farm Platform links our work on grassland-livestock research with many global partners, including the University of Alberta.

EUROPE

We are active in the European Plant Science Organisation and European Technology Platform – Plants for the Future.

AARHUS, DENMARK

Aarhus University is our lead partner in IWMPRAISE, an integrated weed management project, funded under the EU Horizon 2020 programme.

ANKARA, TURKEY

Our local collaborations in Turkey focus on improving disease resistance and on improving yield and nutritional value in wheat.

MEXICO CITY

We collaborate with many international centres, such as the International Maize and Wheat Improvement Center (CIMMYT).

TEXAS, USA

We have installed vertical radar to track insect migration.

KARNAL, INDIA

We lead an Indo-UK Centre for the Improvement of Nitrogen Use Efficiency in Wheat (INEW).



CALI, COLOMBIA

We collaborate in partnerships with CIAT, the International Center for Tropical Agriculture.

BEIJING, CHINA

We are involved in binational initiatives, such as the Centre for the Sustainable Intensification of Agriculture (CSIA).

NAIROBI, KENYA

We have many long-standing partnerships, such as with the International Centre of Insect Physiology and Ecology (ICIPE).

LOS BAÑOS, PHILIPPINES

We have projects funded by the Global Challenges Research Fund, such as one on lipids with the International Rice Research Institute (IRRI).



SÃO PAULO, BRAZIL

We collaborate in many ways, including projects jointly funded by the Biotechnology & Biological Sciences Research Council (BBSRC), EMBRAPA and the São Paulo Research Foundation (FAPESP).

MONTEVIDEO, URUGUAY

Our collaboration with the Instituto Nacional de Investigación Agropecuaria (INIA) is one example of our strategic alliances.

LAGOS, NIGERIA

We appoint Rothamsted International Fellows from all over the world.

ARUSHA, TANZANIA

We coordinate the Africa Soil Information Service (AfsIS), funded by the Bill & Melinda Gates Foundation.

CANBERRA, AUSTRALIA

We have long-standing ties with the federal research agency, CSIRO, and several universities, often focused on improving cereal yields.

LASTING BENEFITS

Falling competitiveness, increasing threats, greater demands, fewer resources. There are solutions.

Agriculture in the UK is at a crossroads. The food chain, from farm to fork, adds £110 billion to the national economy each year, but British farming risks becoming less competitive in an increasingly global agricultural market.

In recent decades, the technological efficiency of agriculture has been lower in the UK than in comparable countries. The UK's productivity is challenged by increasing biotic threats (insects, disease and weeds) to plant and animal health, by resistance to agrochemicals, by declining soil health, and by a slow rate of increase in yield.

A problem-oriented, outcome-driven science approach is needed to address these challenges.

The UK also needs to shape new agricultural policies for the post-Brexit era.

This change is an opportunity for the scientific community to engage in policy innovation, to support the design and testing of evidence-based, forward-looking policies that reflect long-term thinking.

Alongside government strategies and through the National Farmers Union, the UK's primary producers and industry have identified eight priorities for agricultural research and innovation over the next 20 years (see right). These priorities have guided our strategy.

INNOVATION NEEDS FOR BRITISH FARMING

- Digital, data-driven and engineering technologies
- Advanced crop and livestock genetics and breeding technologies
- Interactions between air, soil, water and crop/animal processes within farming systems
- Integrated approaches to management of crop weeds, pests and diseases
- Integrated approaches to management of animal disease within farming systems
- Evidence-based management and valuation of ecosystem service provision from farming systems
- Skills, training and knowledge exchange
- Use of social and economic sciences

Feeding the future, four years on. NFU, 2017.

TACKLING THE GRAND CHALLENGES

Our vision is defined by the need to improve how food is produced and processed, and to increase its nutritional value.

At the heart of our research lies the need to feed a growing world population in a more sustainable manner and, in the process, make British farming both more sustainable and successful.

The 17 Sustainable Development Goals of the United Nations define a long-term vision and strategy that we support.

The goals seek transformative changes in the way food is produced, processed and consumed.

Taking this global view, Rothamsted's science will focus on the sustainable intensification of arable and grazing-

livestock systems in the UK and worldwide.

Building on our unique ability to work across different scales and disciplines, we aim to deliver know-how, data, better practices and new technologies to improve performance, resilience and value.

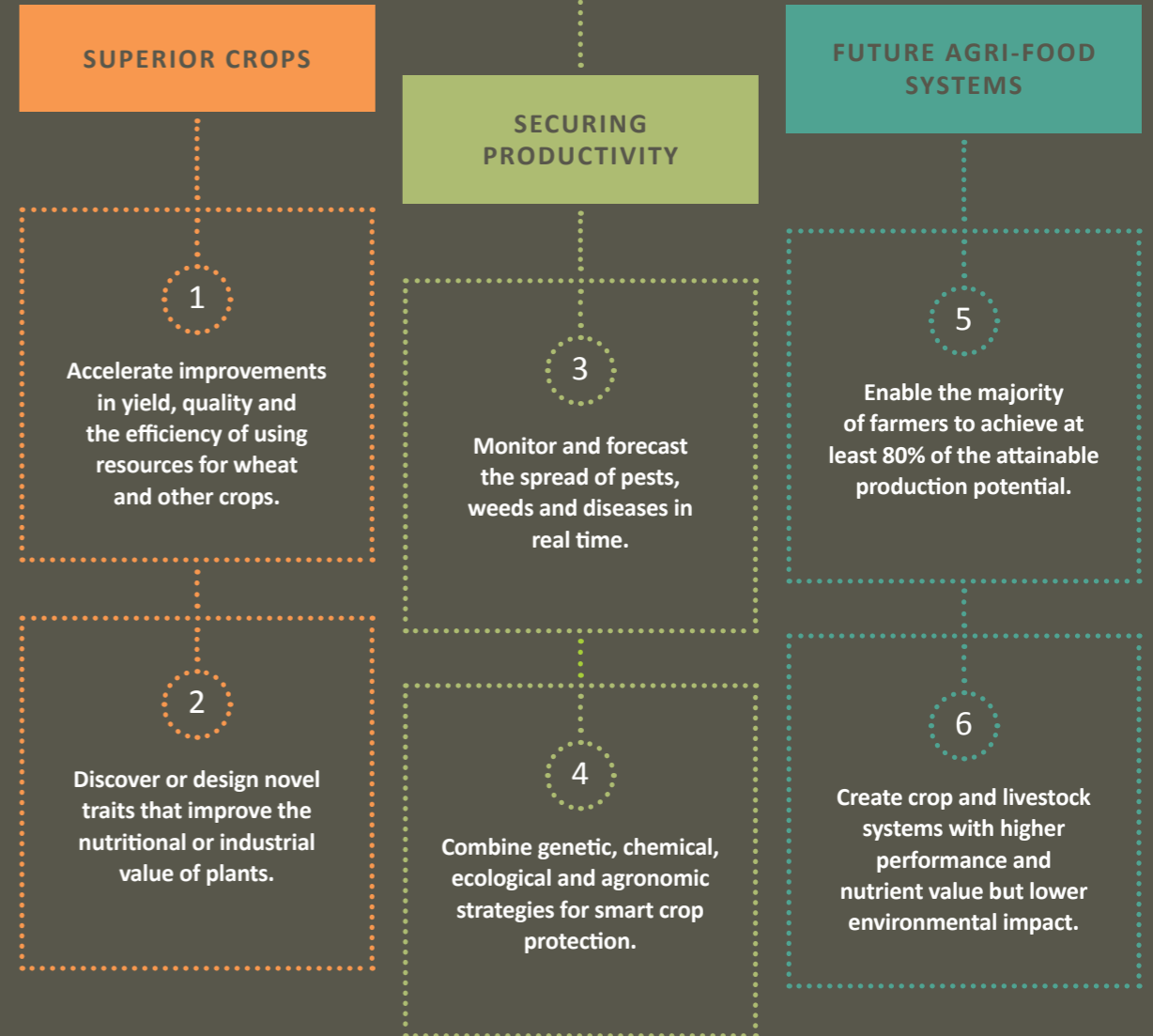
We aim to raise the productivity of crop and livestock systems; tackle weed, disease and insect resistance to agrochemicals; improve soil health; enhance natural capital; reduce agriculture's carbon and nutrient footprint; and add novel nutritional, health and bioeconomical value to crops and other products.

We have identified six Grand Challenges for agriculture, which we address through three major Science Portfolios: Superior Crops, Securing Productivity, and Future Agri-Food Systems.

These portfolios cover our five Institute Strategic Programmes (ISPs) for the next five years to 2022: Designing Future Wheat; Tailoring Plant Metabolism; Smart Crop Protection; Soil to Nutrition; and Achieving Sustainable Agricultural Systems.

Special initiatives, or Flagship Projects, will complement these strategic programmes, enabling us to focus on exciting opportunities that arise as the work progresses.

Our work is supported by strategic funding from the Biotechnology & Biological Sciences Research Council (BBSRC) and by grants from many other sources, including industry.



SUPERIOR CROPS

This portfolio links two Institute Strategic Programmes to explore ways of growing valuable crops efficiently.

We apply an inter-disciplinary approach to understand and improve genetic traits and to tailor their interactions with the environment and their management.

Our aim is to develop novel germplasm, characterised for the next generation of key traits. And we provide that germplasm in a readily accessible form to the wider plant science and breeding communities.

In cereal crops, such as wheat or rice, we focus our efforts on traits related to yield, efficiency in the use of nutrients,

resistance to diseases and insect pests, climate change adaptation, and more nutritious grain.

Agriculture can become a great source of innovations for expanding the wider bioeconomy. Plants not only supply us with food, fuel and fibre; they also serve as a rich source of valuable chemicals, including drugs, dyes, feedstocks for industry, and flavouring and fragrance ingredients. We aim to deliver such novel traits in bespoke crops, and so advance the bioeconomy in the UK and abroad.



DESIGNING FUTURE WHEAT

DFW integrates wheat research from across the UK into one force that maps directly onto international priorities agreed in the G20 Strategic Research Agenda of 2015. The collaboration includes the John Innes Centre, Rothamsted Research, the Earlham Institute, the National Institute of Agricultural Botany, the Quadram Institute, the University of Bristol, the University of Nottingham and the European Bioinformatics Institute.

The priorities cover five main areas: yield potential; nutrient use efficiency; quality and safety of wheat; disease and pest control; and wheat information systems and exploitation of genetic resources.



TAILORING PLANT METABOLISM

TPM will exploit the ability of plants to produce a diversity of high-value products. With our knowledge from basic research on metabolic pathways, we aim to control these natural reactions in a predictable way.

We focus on two groups of high-value products: (1) lipids in oilseed crops, such as *Camelina sativa*, that yield oils for human and animal health and nutrition, and waxes for industrial uses, such as lubricants and cosmetics; and (2) phenolic glycosides, produced by willow (*Salix*), that can be used as starting materials to make many useful chemicals, including drugs.

SECURING PRODUCTIVITY

This portfolio focuses on one Institute Strategic Programme to protect and improve the health of plants and animals.

Globally, 30% of crop yield is lost to insect pests, plant pathogens and weeds. Improving the efficiency and sustainability of crop protection is one of the most accessible ways to intensify agriculture sustainably.

Currently, crop protection relies heavily on pesticides but three factors

threaten this approach: growing natural resistance to chemicals; regulations that limit access to and development of new products; and environmental and human health concerns.

Working with colleagues associated with our future wheat and sustainable intensification programmes, we aim

to deliver a new vision for managing crop health.

Our goal is to limit the incidence, distribution, dispersal, evolution and impact of these biotic threats. We also aim to maximise the efficacy and sustainability of control interventions.



SMART CROP PROTECTION

SCP integrates chemical, genetic, biological, ecological, mathematical and agronomic approaches to deliver more targeted, “evolution-smart” control strategies. We work on real-time monitoring and forecasting techniques for insect and plant diseases, aiming always to be one step ahead of evolution.

We apply a common “gene to landscape approach” in our research on resistance to insecticides, fungicides and herbicides. We make advances in fundamental science relating to plant-pest interactions, to the evolution of pests, weeds and diseases, and to pest population dynamics. This work will lead to novel interventions.

FUTURE AGRI-FOOD SYSTEMS

This portfolio links two Institute Strategic Programmes to close gaps in the productivity and efficiency of crops and livestock.

We are focused on increasing productivity, using resources more efficiently, improving soil health and structure, enhancing biodiversity, reducing carbon footprints, and raising the nutritional quality of crop and livestock produce.

We hope to gain a much deeper understanding of soil processes that

underlie sustainable systems. We apply fresh thinking and methods to address fundamental questions, such as what makes a healthy soil and what causes gaps in yield and efficiency.

We hope to manipulate the underlying mechanisms in an informed way to optimise processes at field, whole-farm and landscape scales.

Our aim is to enable a much more precise management of arable and livestock farms.

We pursue “big data” approaches to look at agricultural systems in a holistic manner. We combine theory with experimentation in the field and at landscape levels to test novel strategies in the real world.

iv

ACHIEVING SUSTAINABLE AGRICULTURAL SYSTEMS

ASSIST questions how productivity gains in agriculture have often been accompanied by unintended consequences for the environment.

Funded by the Natural Environment Research Council and BBSRC, and combining expertise from Rothamsted Research, the Centre for Ecology and Hydrology and the British Geological Survey, the programme has twin aims: to discover if food production can be increased while minimising agriculture's environmental footprint; and to gauge the importance of

biodiversity in supporting production and whether these “ecosystem services” to agriculture can be improved.

At the heart of ASSIST lies a network of farms located across contrasting cropping systems, landscapes and soil types in the UK, including arable and grassland-livestock farms. The programme will combine the best agronomic and ecological knowledge to test practical options for reducing the environmental footprint of agriculture while also closing the gaps in yield.

v

SOIL TO NUTRITION

S2N aims to transfer nutrients more efficiently from soil to crops and livestock, and so yield higher value food from arable and grazing land, rather than lose them as pollutants in waterways or as noxious emissions.

Farming systems constitute inherently complex interactions between a large number of interconnected physical, biological and chemical processes, and so working out

how to achieve our aims is a multidisciplinary operation across many scales, from micro-cellular to macro-commercial.

S2N will identify the metrics necessary to dictate interventions for sustainable intensification. Alternative scenarios for management across scales, from rhizosphere to landscape, will be tested for delivering sustainable crops and livestock.

FROM FISH OILS TO SMART ANSWERS

Growing fish oils in fields (*near right*) and exploring integrated solutions (*far right*) are two special initiatives, or Flagship Projects, at different stages of development.

Omega-3 fish oils or, more precisely, omega-3 long chain polyunsaturated fatty acids are crucial nutrients for humans and animals. In humans, they reduce the risk of cardiovascular disease and other metabolic diseases, such as obesity and type-2 diabetes. But the wild fish stocks that provide them are at the maximum levels of managed sustainability.

Over the past 20 years, Rothamsted researchers have been tackling this challenge.

They have isolated the genes in marine micro-organisms responsible for biosynthesis of omega-3s; identified a suitable plant host, *Camelina sativa* (shown), which is one of Europe's oldest oil seed crops and grown as biomass fuel in North America; and produced genetically modified crops in experimental field trials. These studies have confirmed the promise and utility of this new terrestrial source of omega-3 fish oils.

The challenge now is to move from a research phase to a product development and commercialisation mode. The shift includes the need to obtain regulatory approval to allow the wide-scale cultivation of the genetically engineered *Camelina* that can accumulate omega-3 fish oils.

Such developments also require engagement with the entire agricultural production chain, bulk end-users, such as the aquafeed companies that supply fish farms, and consumers.

This Flagship Project aims to achieve these key steps within the next five years.

Our vision is that, in the long term, the bulk volume of 1 million tonnes of fish oils that are harvested from the world's oceans can be supplemented by production of GM crops on land.

LOOKING FOR FIXES ACROSS DISCIPLINES

Our Integrated Solutions Laboratory, another Flagship Project, aims to find answers to agricultural problems by working across our strategic programmes rather than by trying to isolate a problem and dealing with it separately.

Solutions based on single-target interventions are, at best, a small subset of all possible solutions to the challenges facing the food system; at worst, they create new problems. ISL aims to enable scientists, businesses and policy-makers to find multi-target and synergistic interventions that take into account the key interactions in the production system and food chain.

As a result, the interventions could provide a wider set of control options, more resilient solutions, and a reduction in unintended consequences.

NATIONAL CAPABILITIES

We host three unique experimental facilities, supported by BBSRC and open to scientists everywhere.



LONG-TERM EXPERIMENTS

The LTEs are recognised as a world-class capability. They are used to test hypotheses and to conduct long-term research on crops and land management. Some date from the 19th century. They include newer trials that focus on the value of different organic manures and crop rotations; the Sample Archive (with more than 300,000 varieties of grain, soil and so on); the electronic Rothamsted Archive (e-RA); and two UK Environmental Change Network sites. We are also investigating key scenarios for sustainable intensification.



ROTHAMSTED INSECT SURVEY

The RIS has run two trap networks in the UK since 1964. It now holds the world's most comprehensive data on insects, for scientists, growers, conservation organisations, individuals and policy-makers. The RIS issues alerts of imminent insect threats; it provides medium and long-term forecasts; and it offers data for academic study and theory development. We are broadening its remit to include the detection of genotypic changes in insects, so we can provide earlier warnings of biotypes harmful to agriculture.



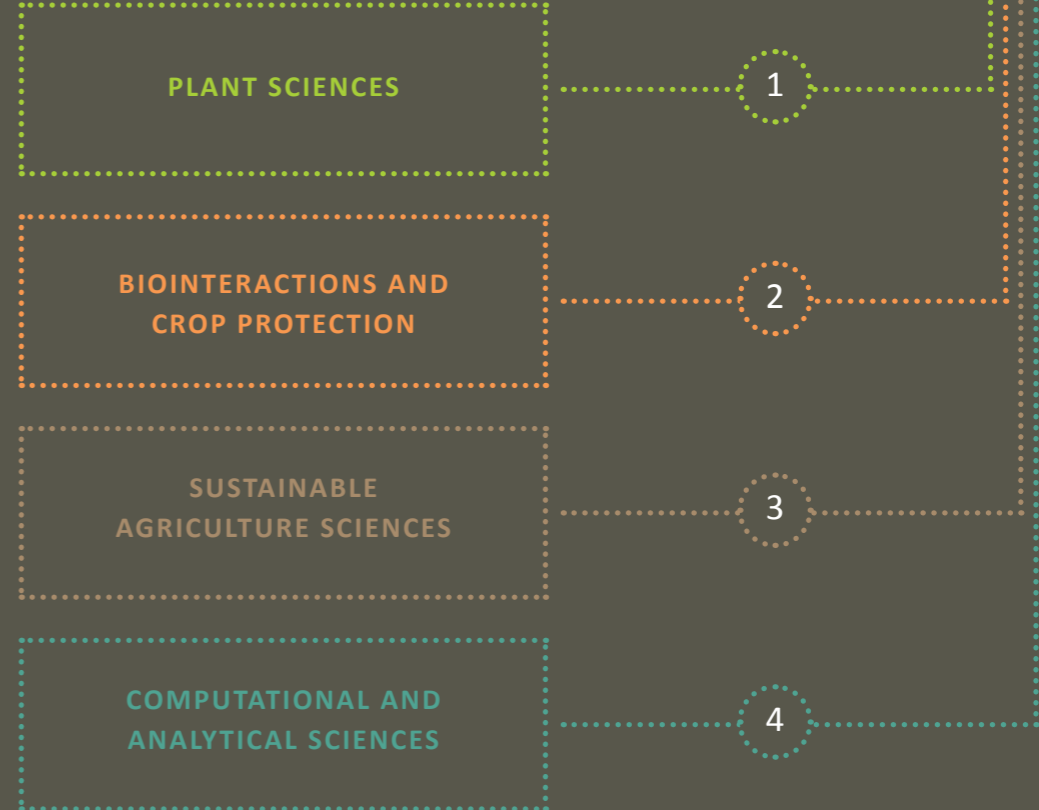
NORTH WYKE FARM PLATFORM

The NWFP uses three 21-hectare farmlets, each under different management scenarios, to study grazing livestock and their associated food chains. The aim is to develop more nutritious food more sustainably. Data generated are freely available online via an open-access portal. We will further exploit the NWFP's potential through our association with the Centre for Innovation Excellence in Livestock (CIEL), and its academic and industrial partners, and from wider research collaboration with universities and other partners.

LINKED DISCIPLINES



From PhD students to world-leading experts, our scientists are the lifeblood of the organisation.



LEAN SCIENCE

Closer ties between researchers and stakeholders will refine and improve performances for both.

We are departing from traditional practice to pursue research of greater and more immediate relevance. We will share our ideas with our stakeholders early in our thinking, and the anticipated outputs as well, and continually engage them as the research develops. We call it “Lean Science”.

This fresh thinking will encourage a more dynamic and responsive approach that is aligned with the needs of users, even pivoting to other ideas when changes of direction are called for. Lean Science will be mutually beneficial: our research will benefit from stakeholder feedback, and stakeholders will benefit from the increased value and usefulness of our research.

We are embedding these principles in our research culture through initiatives that include internal innovation fellowships, “hackathons” and new collaborative ventures for the co-development of innovations with our academic and industrial partners.

Our new **Agricultural Research and Innovation Accelerator (AgRIA)** is one such venture. This fast-start:fast-stop vehicle comes in three basic models: short leap projects of 6–18 months; early entrepreneur projects of 1–4 years; and longer “leaps-of-faith” projects of up to five years. AgRIA projects will cluster as themes; a soils innovation theme is among the first to be launched in 2017.

Another new venture is **FarmInn**. This initiative will enable farmers to test their new ideas rigorously on-farm with Rothamsted’s leading experts, using the best scientific approaches, without the risks associated with innovative practices.



PARTNERSHIPS COME FIRST, AND LAST

We are a proactive and creative hub for agriculture that will become even more internationally vibrant.

Partnership. Innovation. Public engagement. Knowledge exchange. Business development. They are all woven into our new science strategy. We will work with public and private sector partners in a strategic manner to turn excellent research into valuable products with sustainable impacts.

There will be a common agenda, mutually beneficial cooperation, flexible and open innovation, and effective communication. We are strengthening these developments through new strategic alliances with research institutes, universities and businesses, and through new initiatives, such as **AgRIA** and **FarmInn** (see p23).

Rothamsted collaborates with many different industries and is also a founding member of three innovation centres in the UK: **Agriometrics** is the world's first big data centre; the centre for **Crop Health & Protection** brings



ANGELA KARP

Director for Science Innovation,
Engagement & Partnerships

“We expect greater impact and to tap into expertise worldwide”

together industry and academia to help farmers to deal with crop threats; and the **Centre for Innovation Excellence in Livestock** nurtures sustainable production. Our **Rothamsted Centre for Research and Enterprise** provides conferencing, incubation and open innovation facilities.

We will expand our international activities, and focus on research of relevance for low- and middle-income regions. We expect to have a greater impact and to tap into expertise worldwide. **Rothamsted International** will be our primary vehicle. Key alliances will be forged on the basis of complementary scientific excellence, strategic relevance, potential for impact and opportunities for funding and co-investment.

Rothamsted will continue to inform policy-makers as an independent provider of robust evidence that is founded on the best available scientific knowledge. We will engage with groups voicing concerns. We will communicate accurately, through Open Days and through our participation in inquiries, consultations and debates.



BUILDING A BETTER INSTITUTE

We want the right people doing
the right work in the right way.

Our focus is on creating an excellent work environment for everyone and on maintaining the institute's financial sustainability. Stable and diversified funding sources, cost-efficient operations, better use of resources and assets, and recovering costs for internal and external services are all part of our plan.

Enhancing the efficiency of an organisation and its operations requires clear, precise policies with procedures that reflect best practice.

Automation, new tools, process improvements and software will all help us to do more with less.

Our continuing leadership in agricultural science depends on efficient project management, on working well together and on coordinating work at all our sites.

Core to our success is having the right people doing the right work in the right way. And we will be having more of that:

- More talented scientists;
- International fellowships;
- Leadership development;
- Advancing women's careers;
- Employee forum;
- Career progression;
- More PhD students;
- Sports and social clubs.

Not only are we focusing on having the best institute for today, we are also investing in our future. New student accommodation is among developments as we continue to enhance our campus, to improve our delivery of science and to make strategic investments in our research, innovation and partnerships.



DONNA LIPSKY
Director of Operations

“Efficient project management, working well together and coordination”

ABOUT ROTHAMSTED

AGRICULTURE AND SCIENCE SINCE 1843

Rothamsted is a vibrant hub for global science, backed by history and forward-thinking.

More than 500 people, representing over 35 nationalities, work for Rothamsted across four campuses, in multi-disciplinary facilities and on experimental farmland. Our collaborations stretch over 50 countries.

Funding comes from the Biotechnology & Biological Sciences Research Council (BBSRC), the Lawes Agricultural Trust (LAT), and a wide range of other national and international sponsors, including industry.

Our scientists publish 250 to 300 research papers each year and make data, software and other information widely available. We protect key intellectual property and commercialise it in partnership with industry.

Brief History

Rothamsted was founded in 1843 when John Bennet Lawes, the owner of the Rothamsted Estate and a chemical fertiliser pioneer, appointed Joseph Henry Gilbert, a chemist, as his scientific collaborator.

They planted the now renowned classical Long-Term Experiment on Broadbalk field; the experiment continues today. They also secured, through the trust, the future of "agricultural investigations" at Rothamsted Experimental Station. In 2003, RES became Rothamsted Research.

Current Structure

Since 2011, Rothamsted Research has been an independent charitable company, limited by guarantee and governed by a board of non-executive trustee directors. The Chief Executive of Rothamsted is the institute's Director, who reports to the board.

agricultural science. LAT provides land, facilities and funding; BBSRC, part of UK Research and Innovation, funds the institute's research programmes and core capabilities.

Rothamsted, LAT and BBSRC are also the shareholders of the Rothamsted Centre for Research and Enterprise (RoCRE), an incubation space for new businesses from inside and outside the institute.

Rothamsted, LAT and BBSRC are an enduring partnership with a common interest in advancing



Rothamsted Executive Team

- Achim Dobermann**
Director and Chief Executive
- Angela Karp**
Director for Science Innovation, Engagement & Partnerships
- Donna Lipsky**
Director of Operations

LAT Board

- Graham Birch** (Chair)
- Tina Barsby**
- David Baulcombe**
- Ewen Cameron**
- Gordon Conway**
- Donald Curry**
- Charles Godfray**
- Peter Kendall**

Rothamsted Board

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- Richard Bardgett**
- David Baulcombe**
- Russell Brooks**
- Oliver Doubleday**
- Charles Godfray**
- Stuart Jarvis**
- Alastair Leake**
- Paul Leonard**
- Sally Smith**
- Michael Winter**

RoCRE Board

- Zahir Sachak** (Chair)
- Chris Dunkley**
- Stephen James**
- Donna Lipsky**



NORTH WYKE

About 350 hectares of our farmland are in Devon where three experimental farms, just 21ha apiece, are known as the North Wyke Farm Platform.



HARPENDEN

Our headquarters mix modern and heritage architecture, cutting-edge laboratories and, with our sites at Woburn and Brooms Barn, nearly 500ha of experimental farmland.



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