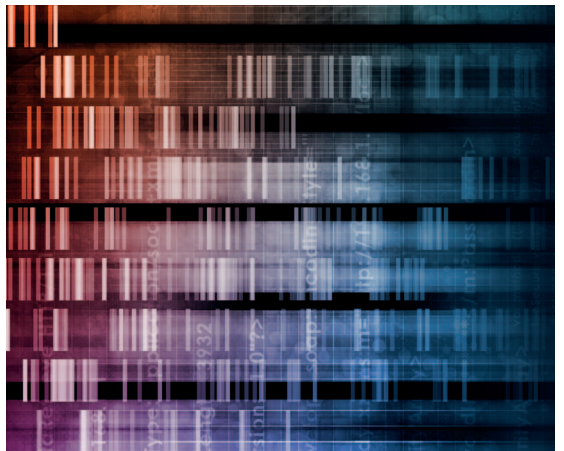




Research Councils UK

Sixty years of DNA



Research funded by the Research Councils provides a vital contribution to the UK's economic growth, prosperity and well-being.

We take a variety of approaches to support innovation and deliver impact from research, including the development of collaborative research programmes, investment in major research capabilities, such as national research facilities, and the support of impact-related capabilities.

Often the impact of research is realised through the combination of several investments over time. The Research Councils seek to ensure that the outputs and outcomes of their funded research have significant long-term benefits for the economy and society. This timeline, one of a series, highlights how investments made in research over the long-term combine to create a significant impact in particular areas. In addition, research in one area can combine with that from another to drive innovation and provide a key contribution to UK growth. For example, Sir Edwin Southern's Southern Blotting technique has culminated in the invention of today's DNA chip, or microarray, technology, which has a wide-range of uses, from forensic analysis to drug discovery, the diagnosis of disease and farming techniques. The worldwide DNA chip market was estimated to be \$1 bn in 2007.



Sixty years of DNA

Decades of RCUK-funded research into DNA has led to the development of tools such as DNA sequencing, fingerprinting and chips that have had a huge impact on technology, health, the environment, society and food security. Professor James Watson and Dr Francis Crick, RCUK-funded researchers, famously described the structure of DNA in the scientific journal *Nature* in April 1953. The work owed a substantial debt to fellow Research Council scientists Dr Rosalind Franklin and Professor Maurice Wilkins. The discovery transformed scientists' understanding of human diseases and treatments and triggered the development of new DNA technologies with enormous economic and health benefits.

Determining the structure of DNA laid the foundation for a genetic revolution that went on to establish in the 1960s that three-letter DNA 'codons' formed the basis of instructions for building proteins. In the 1970s, Research Council scientist Dr Frederick Sanger's DNA sequencing technique and other methods to manipulate and analyse DNA gave scientists the basic toolkit to begin exploring the DNA blueprint.

RCUK-funded scientist Sir Alec Jeffrey's invention of DNA fingerprinting technology has helped to further push forward the fields of genetics and genomics. These developments have had far-reaching impacts on all areas of society, from research into the genetic markers of disease, to helping save endangered wildlife species, the revolution of forensic science and provision of an infallible method of paternity testing.

Technology

1953 Professor James Watson and Dr Francis Crick, using crucial data and the knowledge of Dr Rosalind Franklin, describe the structure of DNA

1975 Dr Frederick Sanger and Dr Alan Coulson develop the 'plus and minus' method for rapid DNA sequencing. With it, they later sequence most of the 5,386 nucleotides of a bacteriophage virus; the first fully sequenced DNA-based genome

1973 Sir Edwin Southern invents the 'Southern blot', a simple technique that made it possible, for the first time, to detect specific DNA sequences within the genomes of complex organisms

1977 Sanger and colleagues introduce the 'dideoxy' chain-termination method for sequencing DNA molecules, also known as the 'Sanger method'

1978 Biogen, one of the earliest biotechnology companies, is formed in Geneva by Kenneth Murray (University of Edinburgh), Walter Gilbert (Harvard), Philip Sharp (MIT), and Charles Weissmann (Zurich)

1980 Celltech, Research Council-supported, is established in the UK as the first EU biotechnology company

1984 Research Council-funded scientist Sir Alec Jeffreys at the University of Leicester invents DNA fingerprinting technology, leading to research into the genetic markers of human diseases, revolutionising forensic science, determining human origins and helping to save endangered animal species

1995 Oxford Gene Technologies (OGT) is established to commercialise Sir Edwin Southern's microarray technology

1996 Research Council scientists produce 'Dolly', the first mammal to be cloned from an adult somatic cell, using the process of nuclear transfer

1998 UK and US researchers, including Dr Sydney Brenner and Sir John Sulston, finish sequencing the *C.elegans* genome – the first complete sequence of a multicellular organism

2001 UK researchers at Imperial College invent new DNA sequencing technology, leading to the founding of spin-out company DNA electronics (DNAe)

2005 Oxford Nanopore Technologies (ONT), a spin-out based on Research Council research, develops a transformative next generation sequencing approach

2006 Solexa, a Cambridge spin-out based on Research Council funded research, launches its first sequencer, the Genome Analyzer. The following year, Solexa is sold to biotechnology company Illumina for \$600m

2007 The Diamond Light Source, which uses highly-powered X-ray crystallography to investigate the structure and properties of biomolecules including DNA and proteins, opens in Oxfordshire

2007 The worldwide DNA chip market is estimated to be \$1bn

2009 The Genome Analysis Centre (TGAC) is established in Norwich. TGAC provides core national capabilities in genome sequencing and annotation and has since contributed to the sequencing of internationally-important genomes

2011 Synthetic Biology researchers show that they can build some of the basic components of bacteria and DNA, which could pave the way for a new generation of biological computing devices

2012 ONT reveal GridION and MinION, third generation DNA sequencing technology that can sequence the three billion base pairs of the human genome in hours. ONT has raised £105m in funding for its development programme

2013 RCUK and NIHR announce funding for genotyping all 500,000 UK Biobank participants. This will advance scientific understanding of the complex interaction between genes and lifestyle in causing a wide-range of life-threatening and disabling diseases

Health

1958 Dr Frederick Sanger wins the Nobel Prize for Chemistry for determining the amino acid sequence of insulin

1961 Dr Mary Lyon conceives the hypothesis of random inactivation of X-chromosomes in mammals. This becomes the Lyon Law in 2011

1977 The first genetically engineered human insulin is produced for the first time using recombinant DNA technology, and introduced into clinical use in 1982, revolutionising the management of diabetes

1980 Sanger wins his second Nobel Prize for Chemistry, sharing it with Walter Gilbert, for their contributions concerning the determination of base sequences in nucleic acids, and Paul Berg for his work on recombinant DNA

2001 Scientists demonstrate that a common variation in the human prion protein gene (PRNP) plays a major role in the susceptibility of developing variant Creutzfeldt-Jakob disease

2002 Researchers sequence the genome of *Streptomyces*, bacteria which provide novel compounds such as antibiotics, potentially worth £240m per year, leading to the creation of several spin-out companies

2003 An international team of researchers, including UK scientists funded by RCUK and the Wellcome Trust, complete the DNA sequencing of the human genome

2009 Research Council scientists develop a method for testing the DNA quality of sperm before it is used in IVF, greatly increasing the chances of conception

2010 Biogen IDEC employs 4,800 staff and generates revenue of \$5bn. One of its main products is a recombinant hepatitis vaccine based on Kenneth Murray's research

2012 Glybera becomes the first gene therapy treatment to be approved for clinical use in either Europe or the United States after its endorsement by the European Commission

2012 The UK government announces funding for a programme to fully sequence the genomes of 100,000 patients with cancer and rare diseases

2013 In a UK study analysing the DNA of 200,000 people, half with cancer and half without, more than 80 genetic markers that can increase the risk of developing breast, prostate or ovarian cancer are discovered

2013 Research Council scientists undertake research to explain how DNA molecules become 'tangled' so that these knots can be unpicked in order to develop new treatments for genetic diseases such as cancer and MRSA

1953

1977

1996

2000

2002

2005

2007

2013

Environment and Society

1988 DNA fingerprinting first becomes available for paternity testing

1987 Research Council researchers use DNA fingerprinting in wild birds for the first time leading to a new understanding of reproductive behaviour in animals

1991 Polymerase chain reaction (PCR) and DNA evidence is presented to a court in the UK for the first time, securing a conviction

2000 First genome sequence of a flowering plant, *Arabidopsis thaliana*. *Arabidopsis* is a model plant, which underpins plant and crop research around the world

1993 The world's first DNA bank for plants is established at Kew gardens. The UK Flora DNA Bank currently holds DNA for 40% of UK plants and is expanding to include fungi

2002 The Research Council funded Genomics Network is established to examine the social impact of the development and use of the science and technologies of genomics

2006 Research Council scientists develop a portable DNA analyser, reducing the time it takes for the police to process DNA samples from 1-2 days to under an hour

2005 The UK Forensic Science Service uses DNA fingerprinting techniques to match 40,000 samples from crime scenes to people's records on the National DNA Database, including 165 homicides, 100 attempted murders and 570 rapes

2008 Environmental genomics reveals the effects that soil pollutants have on earthworms, ushering in a new era of ecotoxicology

2012 Welsh Government abandons plans for a badger cull after a scientific review, incorporating RCUK-funded research on genetic markers of badger dispersal, suggests that culling may be counterproductive

2012 More than 400,000 crimes have been matched against the National DNA Database

2013 Mitochondrial DNA analysis reveals a match between skeletal remains found in Leicester City centre and two living descendants of Richard III, conclusively substantiating evidence that the remains were of the last Plantagenet king of England

2013 Research Council researchers start to decode the ash tree's genetic sequence in an attempt to identify the genes that confer resistance to the *Chalara* ash dieback fungal disease

Food Security

1983 The first genetically modified crop is produced, using an antibiotic-resistant tobacco plant

1994 The first genetically modified crop, a tomato, goes on sale in the USA. The tomato was developed from UK research into fruit ripening

1998 First GM labelling rules are introduced to provide consumers with information regarding the use of GM ingredients in food

2008 High levels of anthocyanins in purple tomatoes created by Research Council scientists could help protect against certain cancers. The anthocyanins come from snapdragon genes expressed in the tomatoes

2011 UK scientists, as part of an international consortium, sequence the genome of the potato, the first major UK crop to be fully sequenced. This will accelerate the development of new varieties to help ensure future food security

2011 DNA sequencing identifies the strain of *E. coli* bacteria on beansprouts which caused the European *E. coli* outbreak. UK researchers contributed to the annotation of the genome as part of global 'crowdsourced' efforts

2012 An international consortium, including RCUK-funded researchers, sequences the bread wheat genome, seventeen times larger than the human genome. Wheat provides 20% of the calories consumed by people globally

2012 A Research Council study of genomic markers for mapping the genome of farmed salmon is published, leading to TSB part-funding the generation of a salmon SNP chip, detecting variations in the genome, to help breed parasite resistance into farmed salmon

2013 RCUK-funded scientists uncover a new genetic technique to determine the species and origins of commonly eaten fish, the latest in a series of RCUK-funded developments on genetic markers to aid marine conservation and prevent illegal fisheries

2013 Horsemeat is found in UK food products. Modern DNA sequencing techniques allow the Food Standards Agency and industry to quickly identify the species from which meat comes

2013 'Golden rice', rice that has been genetically modified to provide vitamin A to counter blindness and other diseases in children in the developing world, is approved for use in the Philippines

Sixty years of DNA

The seven Research Councils are:

- Arts & Humanities Research Council (AHRC)
- Biotechnology & Biological Sciences Research Council (BBSRC)
- Economic & Social Research Council (ESRC)
- Engineering & Physical Sciences Research Council (EPSRC)
- Medical Research Council (MRC)
- Natural Environment Research Council (NERC)
- Science & Technology Facilities Council (STFC)

Research Councils UK
Polaris House, North Star Avenue
Swindon, Wiltshire SN2 1ET
United Kingdom
Tel: +44 (0) 1793 444420
Fax: +44 (0) 1793 444009
Email: info@rcuk.ac.uk
Web: www.rcuk.ac.uk

www.rcuk.ac.uk

Research Councils UK is the strategic partnership of the UK's Research Councils.

We invest annually around £3 billion in research. Our focus is on excellence with impact. We nurture the highest quality research, as judged by international peer review providing the UK with a competitive advantage. Global research requires we sustain a diversity of funding approaches, fostering international collaborations, and providing access to the best facilities and infrastructure, and locating skilled researchers in stimulating environments.

Our research achieves impact – the demonstrable contribution to society and the economy made by knowledge and skilled people. To deliver impact, researchers and funders need to engage and collaborate with the public, business, government and charitable organisations.

Image credits:

Watson and Crick
A. Barrington/Science Photo Library

Dolly the sheep
Philippe Plailly/Science Photo Library

Streptomyces bacterial spores
Microfield Scientific Ltd/Science Photo Library

Diamond Light Source facility
James King-Holmes/Science Photo Library