Science for society

CASE STUDIES

THE ROYAL SOCIETY

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Cover image: Illustration inspired by Feynman diagrams, visual representations describing the behaviour and interactions of subatomic particles in quantum field theory.

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CASE STUDY 1

PISA international comparisons in educational attainment

To inform national policymaking, the Programme for International Student Assessment (PISA)[1] provides a regular assessment of the effectiveness of STEM teaching.

Policymakers are naturally interested in measuring the effect of education and identifying areas for improvement of education systems. Exam results provide one way of tracking progress, but do not necessarily provide insights into the wider utility of STEM education.

Created by the Organisation for Economic Co-operation and Development (OECD), the PISA was designed to provide an internationally standardised approach for assessing the ability of students to apply skills and knowledge, in STEM and other subjects, in real-world settings. Notably, rather than just knowledge, PISA assesses key aspects of scientific and data literacy. (In 2022, PISA assessed students' creative thinking for the first time, but the UK Government declined to participate in these activities.)

In practice, PISA testing takes place every three years, based on a nationally representative sample of 15-year-olds in each participating country. Since 2000, PISA has involved more than 100 countries and nearly 4 million students worldwide. The latest study was published in 2023 and relates to the performance of students in 2022. PISA therefore provides a way to monitor an important aspect of educational activities over time and through comparisons with other countries.

PISA provides national policymakers with a robust, standardised, and consistently applied metric. It can enable them to judge the effectiveness of their education systems at providing students with real-world skills, including in areas of Science, Technology, Engineering and Mathematics (STEM). In several cases, poor PISA scores have triggered national introspection and educational policy reform. In addition, the long-term nature of PISA means that scores can be used to assess the impact of policy interventions. Policymakers can also examine and learn from the approaches adopted by countries achieving consistently high PISA scores.

League tables have drawbacks, however. There may be a temptation for countries to 'game' the system to artificially boost PISA scores and enhance national reputation, and educational policy may be skewed if achieving strong PISA scores becomes an all-consuming goal. Also, scores are inevitably affected by factors outside the education system, such as students' socioeconomic circumstances.

Nevertheless, for those who want to use it constructively, the PISA approach has been proven to provide valuable insights to inform national educational policymaking.

1 OECD, Programme for International Student Assessment. See: https://www.oecd.org/en/about/programmes/pisa.html (accessed 21 April 2026).

CASE STUDY 2

Cancer Research UK's patient and public involvement (PPI)

Cancer Research UK involves people affected by cancer and the wider public in its research because it is desirable, feasible, and, most importantly, leads to better science and better outcomes for patients.

The charity has been at the forefront of efforts to involve untrained groups in a range of scientific activities, such as research-funding decisions and the development and delivery of clinical research. The main rationale is to ensure that research meets the needs of people affected by cancer and members of the public.

Patients and their loved ones are uniquely placed to assess the difference that proposed research could make to the lives of those affected. They can also advise on areas where there are gaps that need to be addressed by research.

The unique value that patients and carers bring is the lived experience of cancer. Patients, carers, and families have a unique real-life, first-person perspective. They also bring skills and experience from their professional and personal lives. PPI ensures that their viewpoint guides multiple aspects of Cancer Research UK's work, from strategy development and priority setting to funding of individual scientific projects. PPI can also help to demonstrate transparency and enable patients and carers to be advocates for its research.

The commitment to PPI is codified into the charity's ways of working and included in its overall organisational strategy and research strategy[2]. People affected by cancer sit on most grant-funding committees and provide feedback on the relevance of proposals and on researchers' plans for PPI and engagement. They comment on the acceptability of the research and methods proposed and review lay summaries or patient-facing materials. PPI is an integral part of grant applications; this helps to embed PPI within the culture of research.

Public representatives also contribute to early-career researcher training, bridging the gap between researchers and people affected by cancer. They provide advice on practical matters, such as trial recruitment, improving diversity, or how to write patient-facing materials.

PPI creates opportunities for mutual learning between researchers and people affected by cancer. Connecting patients and carers to researchers can ensure that researchers better appreciate the goal of their activities. This can be highly motivating, particularly for those who are predominately laboratory-based. It is also rewarding for people affected by cancer: people may feel disempowered by a cancer diagnosis, but PPI can give them hope and agency to create a better future.

PPI places major responsibilities on public representatives, who are carefully selected and provided with support and training. More than 100 public representatives were actively involved in Cancer Research UK's research activities in 2024. Many have been working with the charity for many years — testament to the fact that their contributions are valued and taken seriously.

2 Cancer Research UK. *Our Research Stratgegy*. https://www.cancerresearchuk.org/about-us/our-organisation/our-strategy-to-beat-cancer, https://www.cancerresearchuk.org/funding-for-researchers/our-research-strategy (accessed 21 April 2026).

CASE STUDY 3

RAiSE the bar

The Raising Aspirations in Science Education (RAiSE) initiative has reinvigorated STEM teaching in primary schools in Scotland by empowering teachers and leveraging the power of partnerships.

Primary school is a key stage of education, when children gain the foundational skills and knowledge that will carry them through secondary education and beyond. An integrated approach is taken to STEM teaching, and a key challenge is to ensure that the learner experience in this area is engaging, relevant, and provides skills for learning, life, and work.

An additional challenge is that primary school teachers are typically generalists and relatively few (5 – 10%) have a science-related degree. On average, about one in three primary schools have a science specialist. Teachers may therefore lack some core knowledge and appreciation of recent scientific trends and employment opportunities in STEM-related fields.

In a desire to raise attainment and address inequities, in 2016 the Scottish Government established a cross-sectoral partnership, RAiSE, focused on STEM teaching in primary schools. RAiSE was initially piloted in partnership with Education Scotland (a Scottish Government executive agency), the Wood Foundation (a charity based in Scotland), and local authorities.

Drawing on the recommendations of a report from the Science and Engineering Education Advisory Group[3], RAiSE focused on promoting the competence and confidence of primary school teachers to deliver STEM-related content; RAiSE funding enabled local authorities in Scotland to appoint primary science development officers, who were charged with leading and coordinating professional development activities for primary science teachers and working with schools to embed innovative STEM teaching practices.

The objectives of the project were to build the knowledge, skills, confidence, and enthusiasm of primary science teachers. In an initial evaluation, 71% of teachers reported an increase in their confidence in relation to the pedagogy of science and 76% in relation to the content of science; 87% of teachers reported that the programme enabled learners to experience challenge in their learning[4]. By focusing on creative and practical approaches to STEM teaching, RAiSE also enabled children across the ability spectrum to participate in activities, promoting inclusion.

3 Scottish Government. 2012 *Supporting Scotland's STEM Education and Culture – Science and Engineering Education Advisory Group – Second Report* (2012). See: https://www.gov.scot/publications/supporting-scotlands-stem-education-culture-science-engineering-education-advisory-group/ (accessed 21 April 2026).

4 Lowden K, Hall S, Lusk D and Bravo A. *Raising Aspirations in Science Education (RAiSE) pilot* (2019). See: https://www.thewoodfoundation.org.uk/wp-content/uploads/2019/05/RAiSE-evaluation-report-finalised-.pdf (accessed 21 April 2026).

The project generated resources to support learning and also created new networks and partnerships; local businesses and other employers (including universities and hospitals) were involved in project activities, helping to raise awareness of STEM-related career opportunities at an early age. This was particularly valuable for highlighting to girls the range of STEM careers available. As a result, 77% of teachers stated that they had seen pupils' aspirations increase with regard to science and technology careers.

The project evaluation also noted an increase in parental and community engagement, for example through STEM fairs and other community-based events, illustrating how a focus on STEM in schools can have spill-over benefits on wider society.

Following the successful pilot, the initiative was rolled out more widely, with 27 out of the 32 local authorities in Scotland participating in the scheme.

Image: © iStock.com / SolStock.

CASE STUDY 4

Re-engineering STEM education in Estonia

Starting from a blank state, Estonia has created an educational system that is the envy of Europe.

When Estonia regained its independence in 1991, its education system was in a poor state and dominated by Soviet-era thinking. Recognising the importance of education to its future, Estonian authorities undertook a root-and-branch reform and developed a long-term strategy based on developing the skills young people would need in a technologically advanced society and the need to address inequities.

Rejecting a Soviet style 'command-and-control' approach, Estonia placed its faith in teachers, promoting teacher autonomy. This has been reliant on intensive pre-service training and strong links between Estonia's universities and teaching system, which means that teachers have an excellent background in their specialist subjects. Within a broadly defined curriculum, schools and teachers have considerable scope to adapt and innovate.

Estonia also radically rethought its curricula. Pre-independence, these were content-dense, but the new strategy placed more emphasis on key concepts and principles. A survey of future skills, knowledge, and personal attributes required of young people identified priority skills to be developed, including problem-solving, democratic decision-making, critical thinking, communicating, sourcing and using information, creating and innovating, and taking responsibility for one's own learning. The new strategy also prioritised hands-on activities, project work, and enquiry-based learning.

Another key aspect of the Estonian system has been its commitment to equity. There is no educational segregation until the age of 16 and students must attain a minimum level of competence in core subjects, leading to close attention to the needs of underperforming students. As a result, a high proportion of students leave schools with the skills needed to continue in education or move into the workplace.

The education system has also had a strong emphasis on embracing new technology. Its 1997 *Tiigrihupe* (Tiger Leap) initiative, for example, drove a major investment in computing and information technology networks in schools.

These changes have had a dramatic effect. In 2023 PISA data, Estonia was the highest placed European country for mathematics and science, and second in reading. In 2024, Estonia came top in Europe in a PISA test of creative thinking[5].

The country has faced challenges. The teaching profession has historically not been seen as high status and recruitment has been challenging. Large pay awards for teachers were announced in 2020. The focus on lower achievers has been questioned, with some suggestions that more attention should be given to high-performing students.

5 Education Estonia. *New PISA results on Creative Thinking: can students think outside the box?* (2024). See: https://www.educationestonia.org/wp-content/uploads/2024/06/PISA-in-Focus-125-Creative-Thinking.pdf (accessed 21 April 2026).

Estonia's success story has been based on several key factors. One is the cultural cachet attached to education in the country – seen as a core aspect of national identity. It is also a relatively small country, with a population of around 1.3 million people. In addition, the abrupt change in 1991 enabled it to redesign its education system from scratch, something most other countries cannot do.

Importantly, the post-independence education strategy was supported across the political spectrum, enabling a long-term perspective to be adopted and preventing lurches in policy or disruption due to political point scoring.

> "It's a national choice of how you build your education system and what you are expecting out of it – and in Estonia, we expect equity, we expect that the education system is a social lift."
>
> **Kristina Kallas, Minister of Education and Research, Estonia**

Image: © iStock.com / Drazen Zigic.

CASE STUDY 5

Genetically modified organisms

The introduction of genetically modified (GM) foods in Europe triggered a controversy that continues to have ramifications today.

Foodstuffs have been genetically modified for centuries, mostly through selective breeding. When molecular tools became available, they were used to specifically alter the genomes of food crops. Without much concern, GM foodstuffs were introduced in the US. Yet, when Monsanto attempted to bring GM products to the European market, the company was met with a barrage of opposition.

Most of the public did not hold a strong opinion, but several influential Non-Governmental Organisations (NGOs) were vehemently opposed to GM food. In the UK, the popular press also adopted a negative stance against 'Frankenfoods' (coined by a letter-writer to the *New York Times* in 1992[6]).

Scientists stressed the benefits of GM foods: nutritional improvements could be engineered into crops (Golden Rice, for example, was engineered to make vitamin A, often lacking from diets in low-income countries); and crops could be made drought-resistant or less susceptible to pests. With more mouths to feed and malnutrition rife, GM foods were seen as a solution to major global challenges.

Opponents focused on possible downsides, in three main areas: safety, environmental impacts, and intellectual property. The first two were theoretical concerns, with the precautionary principle frequently invoked. The third issue arose because GM technology was largely in the hands of agribusiness. 'Terminator' seeds particularly raised ire, as these were engineered so that plants were sterile, forcing farmers to purchase seeds each year.

The question was asked: who benefits from this technology? Western consumers had little to gain and might be at risk; environmental harms would be hard to reverse; and farmers would be at the mercy of big business – who appeared to be the main beneficiaries.

The picture was complicated by scientific studies that cast GM crops in a negative light. In the UK, the work of Arpad Pusztai – featured on national television – appeared to show that rats were harmed when fed GM potatoes. When studies were criticised by other scientists, this was seen by some as the scientific establishment closing ranks and squashing dissent.

A scientific consensus soon emerged, that properly regulated GM products were as safe as those developed by other approaches; it was irrational to make blanket judgements about environmental impacts without taking a more holistic view of farming practices.

6 Lewis P. *Mutant Foods Create Risks We Can't Yet Guess; Since Mary Shelley* (1992). See: https://archive.is/EaYYQ. (accessed 21 April 2026).

Yet this initial controversy, and continuing opposition from NGOs, has had a lasting effect. Europe still has predominately negative views about GM crops, and only a handful of countries grow them in any quantity. The EU's stance set back agricultural innovation in the region, with companies ending R&D in the face of a hostile policy environment.

The episode illustrates several key points:

- Public acceptance of new technologies must not be taken for granted. In this case, the technology was pushed by industry with no preparatory engagement with public audiences to explore attitudes and concerns.
- Scientists should be careful about overpromising the benefits of science to society, particularly when other key constituencies, including the media, activist NGOs, and commercial interests, are involved. Failure to deliver benefits may damage scientists' credibility.
- The differing policy responses by UK and Scottish Governments to the same scientific evidence indicates a need for transparency on how and why scientific advice is accepted or rejected.

Image: © iStock.com / zhongguo.

CASE STUDY 6

Montreal Protocol – mending the ozone hole

Scientific evidence and an informed public both contributed to the swift adoption of the Montreal Protocol to eliminate use of ozone-destroying chemicals.

In 1974, US scientists Mario Molina and Sherwood Rowland published an article suggesting that atmospheric chlorofluorocarbons (CFCs), released from aerosol sprays and other products, could be degraded by ultraviolet light, releasing chlorine atoms that were voracious consumers of ozone (O_3)[7]. Since the stratospheric ozone layer protected the Earth from damaging ultraviolet radiation, its destruction by CFCs could have catastrophic effects on health, triggering millions of new skin cancer cases.

The Molina and Rowland paper highlighted a plausible issue, but was not conclusive proof that the ozone layer was being damaged by CFCs. Their conclusions were questioned, particularly by industry sources. However, their work spurred further research, which confirmed their hypothesis; they were later awarded the 1995 Nobel Prize for chemistry.

Although the evidence was not conclusive, US policymakers responded rapidly. By 1978, CFC-containing cosmetics had been banned in the US. US policymakers also concluded that global action was essential, and formed an informal collaboration with other like-minded countries (the 'Toronto Group').

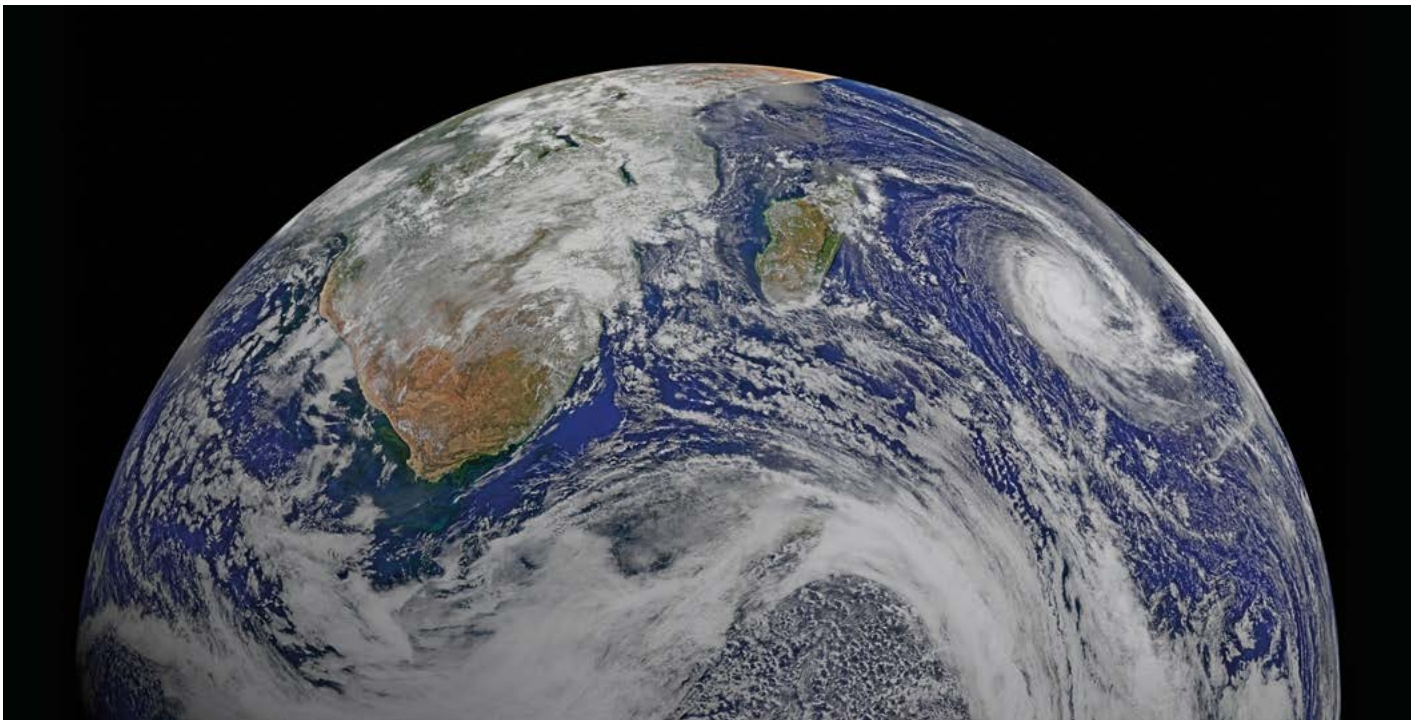
By 1987, 60 governments were involved in discussions to limit CFC use. Eventually, agreement was reached on phasing out of CFCs, with 24 countries initially signing an agreement, the Montreal Protocol, which came into effect in 1989. Over time, further negotiations led to a binding agreement signed up to by all countries. In 2003, UN General Secretary Kofi Annan called the Montreal Protocol 'the most successful environment agreement'[8].

Scientific evidence was crucial to the development of the Protocol, but it was not the sole factor driving political action. Public activities also played a crucial role.

The rapid policy response in the US was driven by several factors. Researchers such as Molina and Rowland were also advocates for action, finding sympathetic ears within key government departments. The raising of public awareness also provided a cause around which environmental activists could coalesce, leading to inventive publicity campaigns and consumer boycotts. In 1987, McDonalds committed to cutting CFCs after being bombarded with letters from children. Despite questioning the science well into the 1980s, even industry eventually came into line, particularly when alternatives to CFCs were developed.

7 Molina MJ, Rowland FS. *Stratospheric Sink for Chlorofluoromethanes: Chlorine Atom-Catalysed Destruction of Ozone* (1974). Nature, vol. 249, no. 5460, pp. 810–12. See: https://doi.org/10.1038/249810a0.

8 UN News. *Annan Calls for Even Greater Efforts to Protect World's Radiation-Shielding Ozone* (2003). See: https://news.un.org/en/story/2003/09/79552 (accessed 21 April 2026).



Above
This composite image of southern Africa and the surrounding oceans was captured by six orbits of the NASA/NOAA Suomi National Polar-orbiting Partnership spacecraft on 9 April 2015. © NASA.

On the scientific side, the landmark discovery of the ozone hole over Antarctica by UK researchers Joe Farman and colleagues was a pivotal moment. This localised destruction of ozone was unexpected (CFCs were predicted to cause a general thinning of the ozone layer). However, CFCs were only one possible explanation for the ozone hole – additional studies were needed to confirm their culpability. Nevertheless, this widely publicised discovery, with graphic visualisations, captured public and political attention.

Although agreement of the Montreal Protocol may hold lessons for other global threats, the relative simplicity of solutions is a stark contrast to the complex global reconfigurations required to tackle climate change. Nevertheless, it illustrates how evidence, scientific and policy advocates, and informed members of the public can act together to drive policy action to achieve real change.

> "This global problem has also shown us that different sectors of society can work together – the scientific community, industry, environmental organisations, government representatives and policymakers – to reach international agreements: the Montreal Protocol on Substances that Deplete the Ozone Layer has established a very important precedent for the solution of global environmental problems."
>
> **Mario Malina, 1995 Nobel Prize address**

CASE STUDY 7

Exeter Science Centre

Exeter Science Centre (ESC)[9] has adopted a distributed approach to public engagement, and plans to establish a presence in multiple sites across the South-West region of England.

The UK has an extensive network of science and discovery centres, which attract millions of visitors each year. However, they are mainly located in cities, which limits their accessibility, and, although they have the scale to mount major exhibitions, large venues are costly to maintain and update.

Established in 2020, ESC has taken a different approach. It envisages a network of smaller connected sites throughout the South-West region. In part this reflects the geography of the South-West, which covers a large area and is relatively sparsely populated, and it reflects a desire to be more agile and responsive, with events and exhibitions that reflect emerging issues as they happen.

The idea for the ESC grew out of conversations between two physicists at the University of Exeter, one completing her PhD and one working in the university's public engagement team. The university has been supportive, and the ESC team continues to support its public engagement work. Given its desire to work with organisations across the South-West, the ESC is set up as an independent entity.

The ESC focuses on the local relevance of global challenges, with environmental science being strong in the South-West. Its aims are to raise awareness of sustainability challenges and to catalyse conversations on approaches to address them. As well as thought-provoking exhibitions, it aims to create spaces for collaboration and action, enabling members of the public to regularly encounter STEM practitioners, contribute to research, and work together on local action, breaking down barriers between the scientific community, the public, and other key stakeholders such as policymakers.

The ESC also aims to be creative in the methods it uses to engage with audiences. The goal is to find a diversity of approaches, including the humanities, that appeal to public audiences who might instinctively feel that science is 'not for them'. These approaches can provide an entry point for such groups to connect to scientific aspects of subjects that they have an interest in – sustainability and the natural world are themes with strong cultural and political dimensions, inspiring prose, poetry, art, and political activism as well as scientific research.

Still early in its evolution, the ESC is working to develop physical spaces in Barnstable on the north Devon coast and Exeter, and is considering other towns and cities in the region as part of its future growth. As it develops a long-term business plan, it is using project funding from a variety of sources to organise activities with a wide range of scientific and community partners.

9 Exeter Science Centre. See: https://exetersciencecentre.org/ (accessed 21 April 2026).

Events and projects in 2024 and 2025 included setting up a water quality monitoring citizen science project in Devon schools, touring activities based on satellite observations of the Earth at community venues, schools, and festivals, community consultations around urban liveability to help steer local data science research, and a creative ‘Our positive future’ event focused on collective imagining of a more sustainable Exeter.

While ‘pop-up’ activities and projects in communities across the region will remain a core element of the ESC, physical centres are seen as a way to reach more people, in more ways, more regularly.

Below
Public engagement event at the Exeter Science Centre. Image courtesy of the Exeter Science Centre.

CASE STUDY 8

Dreamachine and the Perception Census

The multi-award-winning Dreamachine and the Perception Census programmes provided members of the public with a richly rewarding and thought-proving experience, while also generating valuable data for research.

Sensory perception is a fascinating area of interest to scientists, philosophers, and the public alike. How perceptual experiences differ between people has challenged philosophers for centuries, and there is growing scientific interest in exploring these differences. Experimental studies typically involve a small number of participants undertaking simple but rigorously defined tasks. Adopting a public engagement approach can extend studies to a much greater number and diversity of people while also enriching participants' experiences and prompting them to think about the nature of perception and reality.

The Dreamachine programme received multimillion pound support from the Unboxed initiative, which aimed to celebrate UK ingenuity and creativity[10]. A large multidisciplinary team came together to create an immersive perceptual experience, drawing on the surprising finding that stroboscopic light stimulation of closed eyes can trigger vivid visual hallucinations. Almost 40,000 people visited the installation at Belfast, Cardiff, Edinburgh, and London.

Visitors provided feedback on their experience, providing a wealth of material for analysis, including 14,000 visitors' drawings. Curiously, many participants reported feeling uplifted by the experience, which has led to a follow-on research project exploring whether stroboscopic light stimulation might be a treatment for depression.

Dreamachine also incorporated an extensive schools programme, including more than 20 accredited lesson plans that engaged more than a million young people.

The Dreamachine installations and schools programme were accompanied by a large-scale research and engagement project focused on 'perceptual diversity' – how all individuals experience a unique world. The Perception Census was an online experimental and educational journey, consisting of more than 50 perceptual tests, organised in ten modules[11]. These included a mix of visual and auditory experiences, such as illusions and mini-experiments.

Perception Census was presented as a citizen science project, with the aim of exploring perceptual differences between people. The concept of neurodiversity is receiving increasing attention, but often in the context of 'neurodivergence' from the 'neurotypical' – variation in everyday perceptual experience is less well appreciated.

Perception Census gathered a huge amount of data, from nearly 35,000 people in 133 countries. As demographic and other data were also collected, there are rich opportunities to explore perceptual variation by age, geography, or other traits. The data already confirm that perceptual variations are the norm, not the exception.

10 The Perception Census. See: https://perceptioncensus.dreamachine.world (accessed 21 April 2026).

11 Seth A. *Journal Papers*. See:https://www.anilseth.com/research/journals/ (accessed 21 April 2026).

From a research perspective, Perception Census has been a huge success, with a tranche of papers in preparation. Participants have also benefited, partaking in stimulating experiences alongside the opportunity to find out more about themselves (through feedback on how their results compare with those of others), about perception more generally, and by being prompted to reflect on how other people's perceptions and mental experiences might differ from their own.

The Dreamachine and Perception Census programmes were a one-off that benefited from a funding opportunity. Although it is unclear if a project on this scale would be feasible in other circumstances, it illustrates how the internet can be used as a platform for large-scale immersive experiences that are engaging for participants, informative and thought-provoking, and also support high-quality research in cutting-edge areas of science.

Above
Participants for Dreamachine.
© Jennifer Crook.

CASE STUDY 9

Dippy on tour

Taking the Natural History Museum's famed *Diplodocus* skeleton cast on a nationwide tour has increased public access, provided a boost to regional public engagement and economies, and strengthened venues' networking and partnerships[12].

For more than 100 years, the centrepiece of the main hall at the Natural History Museum was a plaster cast of a *Diplodocus* skeleton, affectionately known as Dippy. When the Museum announced plans in 2017 to replace Dippy with a skeleton of a blue whale, a public outcry led to a campaign to 'save Dippy'. It was eventually decided that Dippy could remain in the public eye, through a tour of venues across the UK.

Between 2018 and 2021, Dippy was loaned to eight venues. These were selected to provide access to people from as wide an area as possible, including Scotland, Wales, and Northern Ireland. A diverse mix of venues were chosen, ranging from large regional museums to smaller sites with less experience of major exhibitions, such as Number 1 Riverside, Rochdale, and Dorset County Museum, Dorchester, as well as cultural venues, such as Norwich Cathedral.

Dippy-based temporary exhibitions provided an opportunity to raise local awareness of the natural world, sustainability, research, and STEM career opportunities. Notably, Dippy was not a mobile 'exhibition-in-a-box': each venue created a unique visitor experience, using Dippy as a jumping off point to explore issues aligned with their local thematic priorities.

Dippy proved a highly popular attraction, attracting record numbers of visitors at each venue and 2 million visitors in total during its tour. Each of the venues saw an increase in visitor numbers, which in some cases were sustained after Dippy had moved on (the intervention of the COVID-19 lockdown complicated an assessment of its impact).

The exhibitions had a positive impact on visitors: 81% said they learned something new about the natural world and 71% said it had made them think more about their relationship with it. In addition, 88% of visitors with children said it had inspired their children to find out more about science.

Staff at the Natural History Museum worked closely with colleagues at each venue across multiple areas, such as STEM outreach and commercial activities, and venues recruited new staff and volunteers to cope with increased visitor numbers, some of whom were retained after Dippy had moved on.

Beyond increased visitor numbers, venues reported multiple benefits from Dippy's loan. Surveys undertaken before and during the loan period revealed that the exhibition had attracted new audiences, particularly family groups. In some cases, exhibition-related activities had strengthened local relationships, for example with communities, schools and colleges, and local businesses.

12 The Natural History Museum. *The successes of Dippy on tour* (2022). See: https://www.nhm.ac.uk/about-us/national-impact/the-successes-of-dippy-on-tour.html (accessed 21 April 2026).

At sites with less experience of hosting major exhibitions, the Dippy loan had contributed to organisational development in multiple ways – by building local capacity, improving team-working, and instilling greater confidence, encouraging more ambitious attraction planning.

Many sites felt that the project had strengthened networking, providing more opportunities to learn and share experiences with peer venues. Hosting Dippy had also contributed to organisational bonding and strengthened civic pride.

Below
Bronze diplodicus outside the Natural History Museum. © iStock.com / coldsnowstorm.

CASE STUDY 10

AIDS activism in the US

In the US, AIDS activists challenged medical orthodoxy in the 1980s, leading to fundamental changes in the way that patients and the public are involved in medical research.

The emergence of HIV and AIDS in the mid-1980s triggered a drive to develop new drugs to treat an infection that was, at the time, a death sentence. Research over preceding decades had led to a standardised approach to drug development, based on rigorous clinical trials and approvals by a regulatory body (in the US, the Food and Drug Administration).

Communities particularly affected by HIV and AIDS began to work collectively to address stigma and neglect. They soon turned their attention to drug development, questioning central tenets of the drug development paradigm.

One target was clinical trial design. To assess safety and efficacy, medical researchers favoured randomised controlled trials, ideally placebo-controlled, with homogeneous groups of patients. Since trials were the only way people with HIV could obtain promising treatments, placebo-controlled trials were seen as highly problematic. In addition, patients were often using other treatments, which medical researchers felt could affect trial integrity.

A second key issue was regulation. In the US, a series of medical scandals had led to a safety-first approach that required developers to provide extensive data on safety and efficacy before a treatment could be approved. This required data from clinical trials. Although intended to protect people from harm, this approach inevitably delayed access to new drugs.

The activist community adopted two key strategies. First, they read up on HIV and drug development and were able to discuss core issues as subject-matter experts. In addition, they were able to establish the importance of 'expertise by experience'. No one knew more about AIDS than someone with an HIV infection.

The movement triggered a profound shift in the relationship between medical researchers and patients. As with medicine more generally, the medical research community had adopted a paternalistic, 'doctor knows best' attitude, as medics supposedly held privileged knowledge about disease and how to do science. The HIV/AIDS movement challenged both those assumptions.

For many researchers, the relationship shifted over time from confrontation to engagement, and finally to respect and even friendship. The validity of activists' arguments was recognised and constructive dialogue led to solutions, such as new trial designs and expedited access pathways that enabled patients to access drugs while they were being assessed in trials.

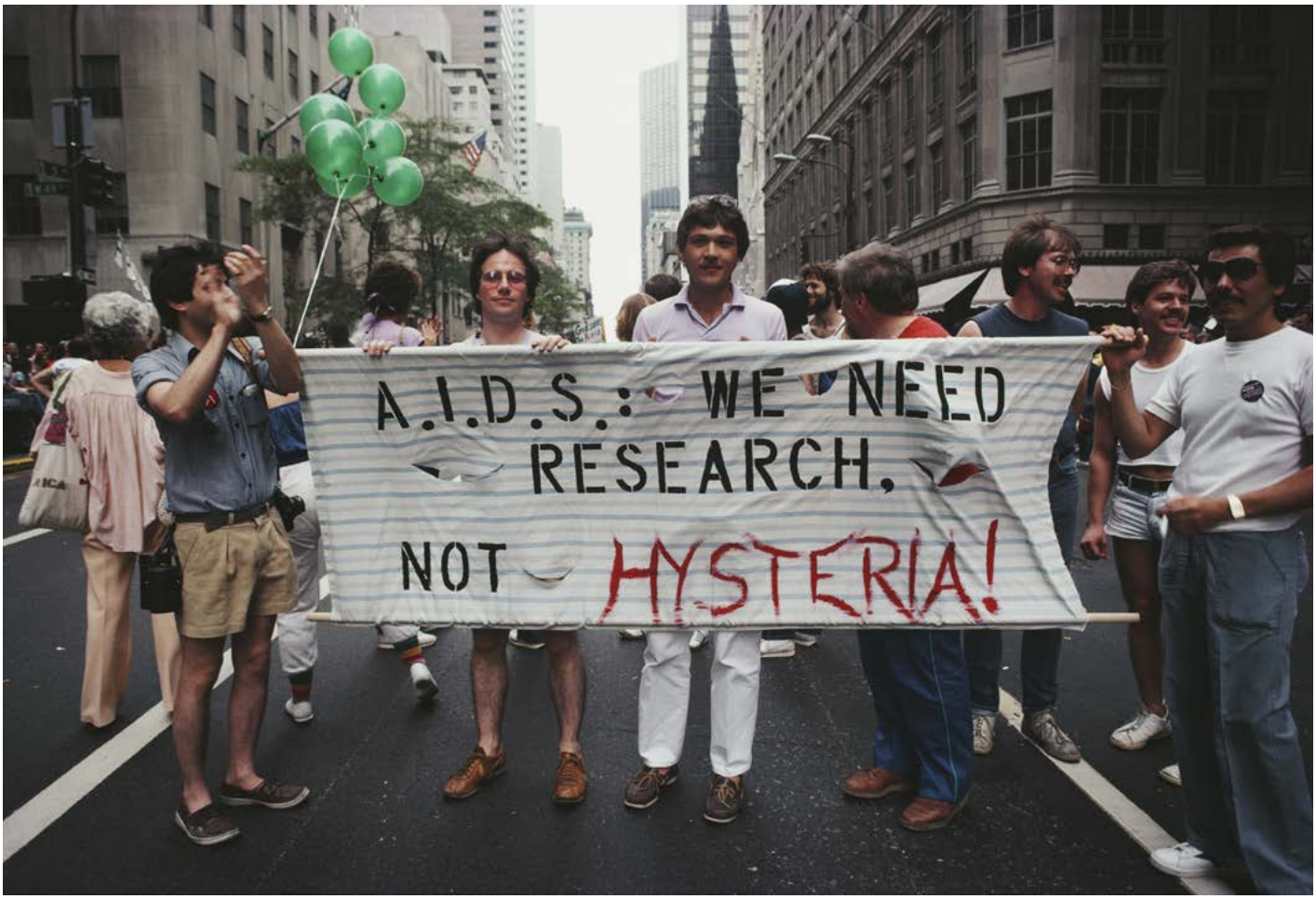
This era had a lasting legacy. The basic model of drug development has endured, but is now more attuned to patients' needs and interests and to the importance of balancing safety and access. Medical researchers have recognised that involving patients and the public is not only morally the right thing to do but also leads to better science and better outcomes. Patient representatives are now far more embedded throughout the drug development network, and are listened to.

The HIV/AIDS episode brought drug development into the public spotlight. Although initially discomforting, partnerships between patients and researchers ultimately proved constructive and enduring — and established the model for future engagement.

"The role of community activists in the drug development process for HIV/AIDS in the United States has had a profoundly positive impact in expediting the availability of safe and highly effective antiretroviral drugs."

Dr Anthony Fauci FRS

Below
Marchers on a Gay Pride parade through Manhattan, New York City, carry a banner which reads 'A.I.D.S.: We need research, not hysteria!', 26 June 1983. © Barbara Alper / Getty Images.



CASE STUDY 11

Big Butterfly Count

For more than a decade, the Big Butterfly Count has enabled tens of thousands of 'citizen scientists' to contribute to scientific discovery and shape national policy.

The term 'citizen science' was not coined until 1989. It refers to the involvement of members of the public in research projects as active contributors rather than passive subjects. The Big Butterfly Count, launched in 2010 and organised by the Butterfly Conversation charity, illustrates how citizen science can deliver mutual benefits.

The count is one of a range of scientific activities carried out by Butterfly Conversation to understand trends in the numbers and distribution of butterfly species in the UK. Complementing more detailed localised studies, the count generates important nationwide data on trends over time, by involving citizen scientists.

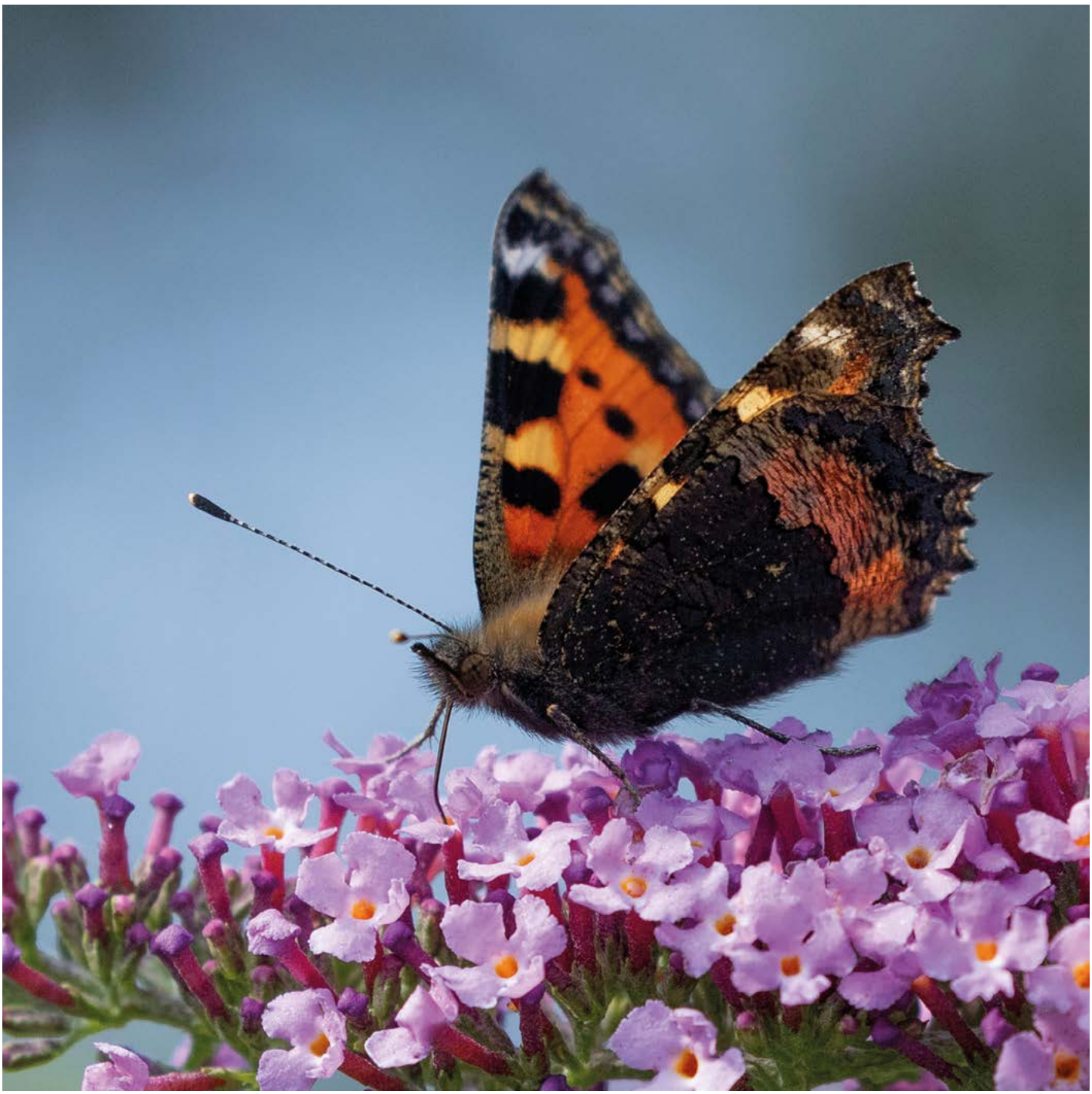
During a three-week period each summer, volunteers spend 15 minutes noting the numbers and types of butterfly they encounter. They can draw upon guidance provided by the charity on identification and enter data through an app or via the Big Butterfly Count website. The number of people contributing data varies each year, but in 2024 125,000 individuals took part, providing data on 165,000 counts[13]. Counters are of all ages, varied backgrounds, and from all areas of the UK.

The count has generated important scientific data, including evidence of the changing distribution of certain species, likely due to climate change. The holly blue, for example, has been identified increasingly far north and has recently been sighted in Scotland, and the Jersey tiger, a moth previously localised to the south coast, has been spotted in London.

There has been widespread concern about the decline in insect numbers internationally. The Big Butterfly Count data indicate that this phenomenon also applies to butterflies, which fell to their lowest ever recorded numbers in 2024. Butterfly Conversation used these data to engage with policymakers at the Department for Environment, Food and Rural Affairs and to argue for restrictions on the use of neonicotinoid pesticides, which can have a devastating effect on insects such as butterflies. Information from each count is fed back to contributors, so they have also been able to contribute to advocacy activities by signing an open letter to the Secretary of State.

The activities appeal to those with an interest in butterflies or the natural world more generally; however, the project is communicated as a scientific activity, with contributors having the opportunity to be part of a scientific team and able to contribute to scientific progress, which undoubtedly adds to its appeal.

13 Big Butterfly Count. *Butterflies fail to shine despite hottest UK summer on record* (2025). See: https://butterfly-conservation.org/big-butterfly-count-results-2025 (accessed 21 April 2026).



Above
Tortoiseshell butterfly, *Aglais urticae*.
© iStock.com / Liz Leyden.

CASE STUDY 12

Mitochondrial donation

In 2015, the UK became the first country to legally approve mitochondrial donation techniques, with strict oversight from the Human Fertilisation and Embryology Authority (HFEA). The medical interventions – popularly referred to as 'three-parent babies' – gives hope to families whose babies suffer the devastating effects of mitochondrial diseases. They also raise ethical considerations and are opposed on various grounds: uncertainty around the long-term consequences, a slippery slope towards more extensive gene editing, a feeling that resources would be better placed elsewhere, or religious concerns around reproduction.

The Human Fertilisation and Embryology Act of 1990 established the HFEA as the independent regulator overseeing use of embryos and gametes in research and fertility treatment. It was updated in early 2001 to explicitly permit the derivation of human embryonic stem cells from early embryos, including those derived using nuclear transfer methods (or 'therapeutic cloning') for research purposes, paving the way for Professor Doug Turnbull and his team at Newcastle University to conduct research on mitochondrial transfer between embryos.

When their landmark paper was published in *Nature* in 2010[14], the journal, university, funders, and the Science Media Centre collaborated. Their joint goal was to provide technical, accurate media coverage laying out the true cost of mitochondrial disease and the hope the research gave to patients and their families.

Journalists were given advance access to the research and experts. Interviews were offered with a patient for whom six babies had died and one surviving son had severe disabilities (and has since died).

Turnbull, who has engaged with media throughout his career and is adept at explaining complex topics in simple terms, was clear that patients' needs had motivated the research: his team wanted to find a way that these families could have children unaffected by mitochondrial diseases.

A research publication provides a news 'hook', but to increase public approval, and to change the law in the face of a coordinated opposition, a sustained period of engagement is needed. At the request of the Secretary of State for Health, the HFEA commissioned a multi-method research and engagement project to look at the social and ethical issues relating to the techniques. This included an online survey allowing people to express their views, while an opinion poll provided quantitative knowledge. Most revealing was an in-depth, deliberative dialogue. Over two sessions, two weeks apart, individuals were given first the scientific and clinical aspects of the research and then later the ethical issues, governance, and regulation. The gap meant they could discuss the issues with their friends and family between sessions, and the process allowed participants to bring their ideas in order to debate the topic more deeply. To ensure no bias, the oversight committee was made up of people who were for and against the research.

The nuanced understanding of the public's views helped to frame engagement with the media, the public, and the policymakers, resulting in a victory for the public understanding of science. From the moment the work entered the public domain, there was huge risk for it to be denigrated and rejected.

14 Craven L, Tuppen HA, Greggains GD, *et al. Pronuclear transfer in human embryos to prevent transmission of mitochondrial DNA disease* (2010). Nature; 465(7294):82-85. See: doi:10.1038/nature08958.

Thanks to the hard work to communicate with the media, and the thorough public dialogue process that allowed two-way communications, misunderstanding was avoided.After detailed reviews on the science, efficacy, and safety of the methods, the Human Fertilisation and Embryology Act was amended to allow mitochondrial donation in human embryos.

As of 2025, eight babies were reported to have been born successfully and have made normal developmental progress[15] using the pioneering technique. There have been reports of other babies successfully born using the same technique around the world, with other nations[16] emulating the proactive, engaged approach taken by the UK, and with clear political and public support.

> "Engaging the public was a critical step in informing Parliamentarians' decision to amend the HFEA Act. Without explaining the complex scientific and clinical issues, and listening to their concerns, this would not have been possible."
>
> **Sir Doug Turnbull FMedSci FRS**

Above
Newborn baby with mother.
© iStock.com / FatCamera.

15 McFarland R, Hyslop LA, Feeney C, *et al*. *Mitochondrial donation in a reproductive care pathway for mtdna disease* (2025). N Engl J Med;393(5):461-468. See: doi:10.1056/NEJMoa2503658.

16 Australian Government Department of Health, Disability and Ageing. *Mitochondrial donation*. See: https://www.health.gov.au/our-work/mitochondrial-donation (accessed 21 April 2026).

CASE STUDY 13

DeepMind

Google DeepMind has used podcasts, and more recently YouTube video versions, to raise awareness of developments in AI research and application.

According to some, AI will either lead to humankind's downfall or usher in a new era of wealth and prosperity. Since the first appearance of Large Language Models (LLMs), they have been assimilated into business and leisure with remarkable speed; but LLMs are only one aspect of a diverse field advancing at a dizzying pace. Many specialists and non-specialists alike are keen to separate hype and doom-mongering from reality.

Since its launch by Demis Hassabis, Shane Legg, and Mustafa Suleyman in 2010, Google DeepMind (originally just DeepMind before it was absorbed into Google as a subsidiary company) has been at the forefront of developments in AI and machine learning.

It operates as a hybrid academic–technology enterprise, with strong in-house research programmes and many academic collaborations, alongside the development of tools for external clients and innovations for its parent company. In addition, its spin-out company, Isomorphic Labs, is using AI tools to accelerate drug development.

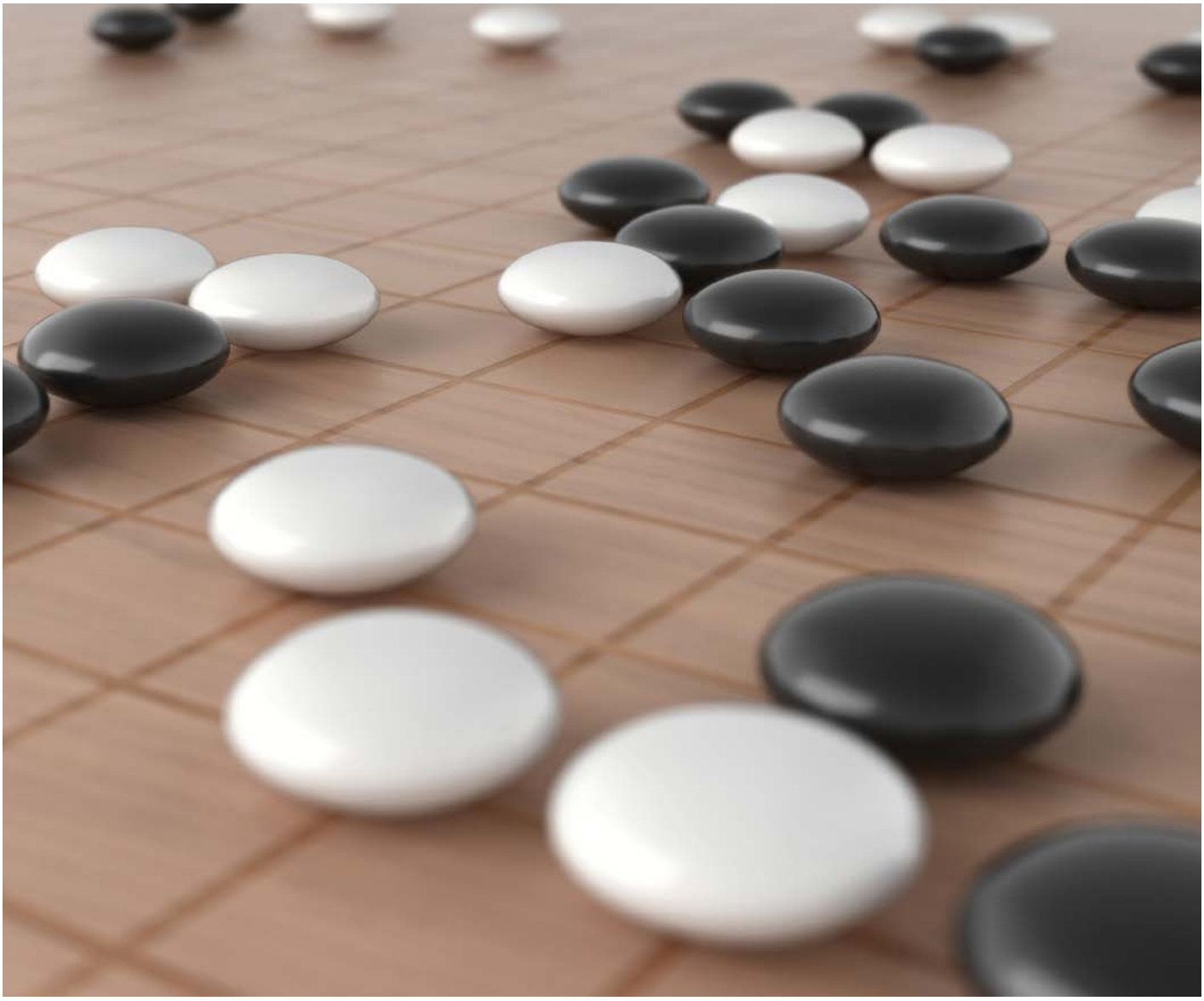
One of its landmark achievements was the development of AlphaGo, an AI system that taught itself to play the ancient and immensely complex Chinese game of Go and ended up beating the then world champion. Google DeepMind has also revolutionised the field of structural biology, developing AlphaFold to predict three-dimensional protein structures based on amino acid sequences – an advance that underpinned the award of the 2024 Nobel Prize in chemistry to Demis Hassabis and John Jumper.

In 2019 Google DeepMind launched a podcast series to raise public awareness of developments in AI. At the time, podcasting was beginning to take off as a popular channel of communication. To ensure a professional production, it engaged mathematician and author Hannah Fry to be the podcast presenter.

The first series of podcasts focused on in-house Google DeepMind experts, including Demis Hassabis. Some episodes focused on novel research developments, for example following the publication of new research papers, others have looked at practical applications of AI in different sectors.

In 2024, the team switched to YouTube videos, in recognition that this was an increasingly popular way for people to consume content[17]. To maintain choice, all videos are also available as podcasts. The topics covered have diversified, with some episodes looking at broader issues such as the prospects of artificial general intelligence and sentient AI, as well as AI safety and regulation.

17 Google DeepMind: The Podcast. See: https://youtube.com/playlist?list=PLqYmG7hTraZBiUr6_Qf8YTS2Oqy3OGZEj&si=B9snY5oVaCISt Spy (accessed 21 April 2026).



The podcasts and videos are popular, attracting hundreds of thousands of viewers/listeners. Both experts in the field and curious non-experts are tuning in to gain accessible but informed insights into the current state of AI and what the future holds.

Google DeepMind's activities illustrate how a company at the forefront of new technology can contribute to more informed public debate about technological advances. The inner workings of AI systems may be unfathomable to most, but some of the mysteries can be dispelled by high-quality communications that involve scientists and technologists whose work will have a profound impact on the future of the world.

Above
Go game.
© iStock.com / fpm.

CASE STUDY 14

Scientific evidence in the courtroom

Scientific evidence can be critical in determining guilt or innocence, but the delivery of justice depends on both the quality of evidence and its reliable interpretation.

In courtrooms, judges or juries weigh up evidence, often including scientific evidence, and decide on guilt or innocence. The reliability of this evidence depends on several factors, including the appropriateness of the techniques used, how well analyses were conducted, and the robustness of statistical analyses. Although many techniques are well-established, forensic science evolves, and the outputs from increasingly complex technologies or analytical techniques are being presented to court.

Courts can receive guidance on the interpretation of evidence from expert witnesses. Unlike 'standard' witnesses, expert scientific witnesses can provide an opinion on the evidence presented. It is the responsibility of judges to decide what scientific evidence is admissible, whether expert witnesses are needed, and whether proposed expert witnesses are suitably qualified.

In England and Wales, there are grave concerns about the quality of forensic evidence being presented to courts and the risk of miscarriages of justice. Forensic science services are provided by private companies, but this sector has been in marked decline, largely due to the drive to reduce costs within the justice system. Police services have increasingly turned to in-house forensic analyses and the lowest-cost approaches, which threatens impartiality and quality of evidence. The academic discipline of forensic science is also in decline, in part because it is not included within the REF.

Furthermore, although expert witnesses are providing a service to the court, they are proposed by prosecution or defence teams. This can lead to the favouring of witnesses thought likely to support interpretations favouring one side or the other. With the justice system tilted in favour of the prosecution, defence teams may struggle to mobilise suitable expert witnesses.

While recommendations have been made to address these systemic challenges, over the longer term an increasing focus on scientific literacy could help to improve the interpretation and use of scientific evidence[18]. Judges and juries both need to weigh up scientific evidence, and consider its strengths and weaknesses and the degree of uncertainty associated with conclusions. Increasingly, this requires wide-ranging critical thinking and literacy skills, including data, AI, and scientific literacy.

Judges typically prepare for cases involving specialist technical evidence. To support these efforts, the Royal Society and Royal Society of Edinburgh have developed 'primers' on key areas of science, as part of a wider programme of work strengthening relationships between the justice system and academic sector. The effect of these activities would be enhanced by a stronger foundation in STEM literacy among the judiciary – most of whom have had little exposure to STEM during their education – and for jurors.

Science has demonstrated its capacity to confirm guilt, to solve cold cases, and to overturn miscarriages of justice. Reform of the justice system, allied to an enhanced societal focus on STEM literacy, will be essential for maintaining public confidence in the criminal justice system[19].

18 Westminster Commission on Forensic Science. *Forensic Science in England and Wales: Pulling Out of the Graveyard Spiral* (2025). See: https://futurejustice.org.uk/wp-content/uploads/2025/06/FS_Digital_latest.pdf (accessed 21 April 2026).

19 The Royal Society. *Science and the Law: Science in the interests of justice – A conference report* (2024). See: https://royalsociety.org/-/media/about-us/what-we-do/science-in-the-interest-of-justice-conference-report.pdf (accessed 21 April 2026).

Above
Statue of Lady Justice, the Old Bailey.
© iStock.com / georgeclerk.

CASE STUDY 15

Co-creating the social licence for geoenergy exploration

Public confusion about geoenergy initiatives stimulated a programme of public engagement activities that has strengthened mutual understanding and provided a solid foundation for geoenergy research.

The geoenergy field aims to develop low-carbon, sustainable energy-generation technologies based on the thermal storage properties of the Earth. To understand the potential to extract thermal energy stored beneath the Earth's surface, the Natural Environment Research Council (NERC) asked the British Geological Survey (BGS) to build and run three geoenergy observatories, funded in 2017 by the UK Government.

The UK geoenergy observatories, in Glasgow, Cheshire, and Cardiff, were tasked with gathering data about the subsurface environment and advancing the development of new, sustainable energy technologies, providing outstanding facilities for research in subsurface thermal energy transfer and storage.

In 2018 there was intense public debate about the UK's energy needs: unfortunately, discussion of geoenergy became conflated with fracking, with significant local opposition to the establishment of geo-observatories. Public opposition threatened to derail observatory development, which could have led to the UK falling behind other countries in exploiting subsurface energy potential.

To address this challenge, NERC, the BGS, and geological research groups worked with Sense About Science to better engage the public. Together, they convened engagement sessions with people from a range of experiences, backgrounds, and familiarity with the issues to explore views on geoenergy, future energy, and the role of the BGS.

Using its 'public-led, expert-fed' approach, Sense About Science started by collating the concerns, questions, and existing knowledge that people had, and then worked with the public and researchers to determine what insights and involvement might address these concerns and questions. Transparency quickly emerged as a key theme.

Sense About Science and the BGS helped the geologists advising on the project to develop a collaborative team with members of the public, community groups, environmental campaigners, open data experts, and other researchers. This team worked together to co-create a website where the research proposals submitted to the observatories could be tracked[20].

20 The UK Geoenergy Observatories. See: https://www.ukgeos.ac.uk/ (accessed 21 April 2026).

Left
Geyser at Mutnovskaya geoenergy station, Russia. © iStock.com / Anzhela Kolentsionok.

Teams worked together to develop explanations of the ambition of the sites and how they operated. These addressed the concerns that had been raised in earlier dialogue, and were targeted at a variety of groups, including people with a casual interest, local residents, and specialist researchers. The public participants extended their contribution, helping to co-create the web platform, how the work was described, and the way that the information was organised.

More broadly, the BGS has built on this experience to integrate community perspectives into its planning. It has piloted new forums for public dialogue about the infrastructure and research needed to underpin climate change mitigation and ensure fuel security.

CASE STUDY 16

Popular science writing

The past two decades have been a golden age of popular science writing[21]. A recent drop-off could signal a need for new voices to reinvigorate the field.

Book such as Rachel Carson's *Silent spring* and Bill Bryson's *A short history of nearly everything gene* illustrate the profound impact that popular science books can have on the public consciousness, and more indirectly on public policy.

Using data from NielsenIQ, the Royal Society has explored recent trends in popular STEM book publishing. In 2000, just over 2% of non-fiction book sales fell into this category – 1.2 million in total. Since 2000, the absolute number of popular STEM book sales and their contribution to total non-fiction book sales have increased markedly. Both metrics peaked in 2019, when more than 5 million popular science books were sold (6.2% of total non-fiction sales).

During this peak period, popular STEM books regularly featured in the top 100 best-selling books. In 2019, 12 of the top 100 books fell into this category. In this year, record numbers of different popular STEM books were purchased – just over 27,000.

Sales have subsequently shown a slight decline from this peak, falling to 2.9 million in 2024, 4.4% of total non-fiction sales. The number of popular STEM books purchased has fallen slightly, but remains above 20,000, compared with just over 5,000 in 2000. Popular STEM titles in the top 100 dropped to four in both 2023 and 2024. However, sales remain double those seen in 2000.

Certain fields have shown particularly strong sales growth. These include 'natural history: general', where sales have held up beyond the 2019 peak (exceeding half a million in 2021, 2022, and 2023), illustrating strong public interest in the natural world. Similarly, 'environment and ecology: general interest' books were relatively popular in the mid 2000s, and have surged in popularity since 2019. There has also been a steady rise in popular science books related to plants.

Books on inventions were particularly popular in the early 2000s, and sales increased in 2023 and 2024, possibly linked to AI. Autobiographies have become more popular in the past decade, particularly around 2018 – 2020, with sales exceeding one million in 2019 (mainly thanks to Adam Kay, of *This is going to hurt* fame).

21 The Royal Society. *The Trivedi Science Book Prize*. See: https://royalsociety.org/medals-and-prizes/science-book-prize/ (accessed 21 April 2026).

In part, these trends reflect the rise of celebrity science writers – popularisers such as Dava Sobel, Yuval Noah Harari, and Sir David Attenborough, as well as professional scientists who are adept at communicating complex scientific concepts, including Richard Dawkins, Stephen Hawking, Brian Cox, and many others. Tie-ins with television series have helped to boost sales. Popular science book prizes, including those organised by the Royal Society, have provided further impetus to the field.

Having peaked in 2007, non-fiction book sales in the UK are on a gently declining trend. For a decade, popular STEM books bucked this trend, but sales volumes and the proportion of total sales have both fallen in recent years. There may now be opportunities for a new generation of communicators, from a more diverse range of backgrounds, to reinvigorate the field.

Below
The Royal Society Trivedi Science Book Prize shortlisted authors 2025, (left to right) Tim Minshall, Simon Parkin, Neil Shubin, Sadiah Qureshi and Masud Husain.

CASE STUDY 17

Siemens Mobility

Siemens Mobility, a division of Siemens that specialises in rail transport, participates in public engagement initiatives that are particularly evident at the local level near its manufacturing and infrastructure sites, including the Goole Rail Village site in East Yorkshire[22].

STEM education in schools has been a major focus of Siemens Mobility's public engagement, with the goal of encouraging children to consider careers in engineering[23]. At the Goole Rail Village site, Siemens Mobility has partnered with Primary Engineer (a national charity) to deliver STEM education in local schools. As part of this initiative, STEM volunteer ambassadors from Siemens Mobility have provided training to teachers and delivered rail-themed engineering workshops for children. Some of these STEM ambassadors from Siemens Mobility returned to the schools they attended as children, noting the 'full-circle opportunity' that engineering can provide. Other initiatives include site tours of the Goole Rail Village for schools as part of National Manufacturing Day, in partnership with Make UK and The Work-wise Foundation[24].

Another aspect of Siemens Mobility's public engagement activities in Goole involves supporting inclusive employment and upskilling opportunities in the local area. For example, Siemens Mobility has delivered an internship programme at the Goole Rail Village site for young people (aged 18 – 24 years) with special educational needs and disabilities. The internship was delivered in collaboration with charities and education providers that support adults with learning disabilities, including DFN Project SEARCH, Selby College, and Hft.

Beyond STEM education and skill development, Siemens Mobility participates in various other outreach activities in Goole that may support building trust within the community: the company has facilitated employee volunteering at local organisations such as a food bank, sponsored events such as Goole Pride, and fundraised for various local charities.

The public engagement activities from Siemens Mobility in Goole demonstrate how large employers can tailor their outreach to a community level, with a long-term view of fostering the development of a skilled local workforce and building support from the local community. These initiatives are often enacted through partnerships with charities, education providers, and other regulated organisations, highlighting the value of working with partners that can support good practice (particularly when engaging vulnerable groups such as children) and meaningful engagement.

22 Siemens Mobility. *Social Value Report* (2024). See: https://assets.new.siemens.com/siemens/assets/api/uuid:40df9492-9f9e-4382-9234-1e3fbc2217b6/SM-Social-Value-Report-2024_original.pdf (accessed 21 April 2026).

23 Siemens Mobility. *Siemens Mobility's Goole Rail Village inspires the next generation of engineers at local schools* (2025). See: https://news.siemens.co.uk/news/siemens-mobilitys-goole-rail-village-inspires-the-next-generation-of-engineers-at-local-schools (accessed 21 April 2026).

24 Siemens. *Siemens opens doors to inspire the next generation on National Manufacturing Day* (2025) See: https://news.siemens.co.uk/news/siemens-opens-doors-to-inspire-the-next-generation-on-national-manufacturing-day (accessed 21 April 2026).

The Royal Society is a self-governing Fellowship of many of the world's most distinguished scientists drawn from all areas of science, engineering, and medicine. The Society's fundamental purpose, as it has been since its foundation in 1660, is to recognise, promote, and support excellence in science and to encourage the development and use of science for the benefit of humanity.

The Society's strategic priorities emphasise its commitment to the highest quality science, to curiosity-driven research, and to the development and use of science for the benefit of society. These priorities are:

- The Fellowship, Foreign Membership and beyond
- Influencing
- Research system and culture
- Science and society
- Corporate and governance

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