



BANK OF ENGLAND

Speech

Science and banknotes

Remarks given by

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I'm delighted to be here this evening to explore the links between science and banknotes, a topic which seems even more appropriate the day after we announced the great scientist Alan Turing will be celebrated on the new £50 note.

I am also pleased to be here in a personal capacity. As Chief Cashier with responsibility for our banknotes it is a peculiar honour to be able to speak in a room that has featured on one of those notes – as this very lecture theatre did on the £20 note, which depicted Michael Faraday, who himself often lectured here.

Though thanks to a quirk in that note's design I can say for sure I am not the first Bank of England staff member to be pictured here; a section of the audience in the Faraday note are minute portraits of the then banknote design team, one of whom is still working at the Bank. As far as I'm aware he has yet to find a way to include himself in any of our other banknote designs – including the design we unveiled yesterday for the next £50 note featuring Alan Turing.

As the central bank of the United Kingdom we have a wide range of responsibilities such as setting interest rates, regulating banks, setting rules for the financial system and storing gold. All of this is vital to our mission of maintaining monetary and financial stability for the good of the people of the United Kingdom. As far as my job goes, that means maintaining confidence in the physical currency by producing high quality banknotes that people can use with confidence.

We also understand the cultural importance of our banknotes. Beyond their worth for transactions or as a store of value, notes are often seen as an important symbol of our country, history and the society we are today.

This importance is why we have, in recent years, sought to invite the public to make nominations for the characters we should celebrate on our notes. In November last year we asked people to Think Science and nominate a scientist to feature on the new polymer £50 note. The response was staggering. Almost 230,000 people made nominations on our website, evidence of the well-deserved pride people in the UK have about our scientific history.

I was delighted by the response. But this left me and my fellow members of the Banknote Character Advisory Committee with the difficult job of whittling down the 989 eligible scientists to a shortlist of just 12 options.

Reading the biographies for each of the nominations over the Christmas break I was struck by the incredible breadth of scientific achievement in the UK. Every field was included, from astronomy to zoology and everything between – even fields that I have to confess, as an economist, I had heard little about before like crystallography and chromatography. There were multiple Nobel Prize winners, many presidents of this very

Institution and a number of people whose achievements in the UK are now celebrated the world over for reasons as diverse as ending small pox to improving the safety of mines.

But the span of this list was not the only aspect that struck me. It was also its diversity. The range of people nominated amazed and inspired me as I hope it will others.

For starters, given the recent and necessary focus on encouraging more women and girls into STEM subjects and careers it was heartening to see so many women on the list. Around a third of the eligible nominations were for women – quite something given the historic barriers to education and careers that many of these women will have faced, and evidently overcame. Hopefully, these women and their stories will provide encouragement to any women considering a career in science today.

This theme of success in the face of adversity is even more pertinent when considering the nominations we received for Black, Asian and minority ethnic scientists. Their numerous achievements were often made in the face of appalling prejudice and disadvantage, making them even more impressive.

There were scientists nominated from every part of the UK, and many others who came to the UK later in life and contributed enormously to society and science here. There were people from practically every decade from the time of Elizabeth I to today, of practically every religion and many different backgrounds and life experiences.

I sincerely hope that this process and the light it has shone on the breadth of scientific achievement in the UK will go some small way to supporting those working towards more diversity in science and inspiring future generations of scientists.

There were so many individuals that were worthy of recognition that it is fair to say we had a very difficult job narrowing down the nominations. Thankfully, I did not have to undertake this task alone. Alongside me on the advisory committee were eminent scientists Dr Simon Singh, Professor Simon Schaffer, Dr Emily Grossman and Dr Maggie Aderin-Pocock MBE as well as the permanent external members of the character committee Baroness Lola Young, Professor Sir David Cannadine and Sandy Nairne. I and Ben Broadbent, the Bank's Deputy Governor who chaired the Committee, would like to thank them for their help in this process. Their invaluable knowledge was essential in turning this impressive list of nominations into a truly inspirational shortlist.

We, as a Committee, wanted to ensure that the shortlist of candidates we selected to put before the Governor not only reflected the extent of scientific achievement in the UK but also the diversity of the nominations. Hopefully the 12 options – covering 14 scientists – that we decided upon, do this justice.

Nobel Prize winners like Paul Dirac and Frederick Sanger sit alongside Mary Anning, whose self-taught palaeontology shows that great science is achievable by anyone with a great and curious mind. Mary Anning was a firm favourite among schoolchildren, and I received lots of fantastic designs for banknotes featuring her most famous discovery – a complete Plesiosaurus skeleton.

Dorothy Hodgkin is on the list. She was the first (and to date only) British woman to receive a Nobel Prize in the sciences. Her discovery of the structures of penicillin, vitamin B12 and insulin have had a lasting effect on medical science, and helped improve the lives of millions of people. Rosalind Franklin, a fellow x-ray crystallographer, is also on the list for her important work in the understanding the structure of DNA.

There is Stephen Hawking, who overcame the diagnosis of motor neurone disease at the age of 21 to transform the field of cosmology and inspire millions around the world with his books about time and the universe. James Clerk Maxwell, who undertook ground-breaking work on electromagnetism. And Charles Babbage and Ada Lovelace, who recognised the potential for machines to make calculations more quickly and accurately than humans.

There are also scientists on the list who came to Britain to take advantage of the opportunities here to contribute to a global scientific endeavour. Srinavasa Ramanujan, who grew up in India and was invited to study mathematics at Cambridge, despite having no formal qualifications, crossing the world and leaving his family behind to pursue his love of mathematics – and in doing so solve many previously unsolvable problems. William and Caroline Herschel, the brother and sister astronomy team who came to England from Germany pursuing their passion for astronomy with self-built telescopes. And Ernest Rutherford, who came to the UK from New Zealand, and uncovered the properties of radiation, revealed the secrets of the atom and laid the foundations for nuclear physics.

Any one of the characters on the shortlist would have been a worthy and inspiring choice for the new £50 note. Unfortunately, scientific achievement in the UK is too large to fit into a single banknote – even if it is the largest we print. But I hope that the selection process provides an opportunity to celebrate all the shortlisted characters and their legacies.

The final choice for the character falls to the Governor of the Bank of England, Mark Carney. After much discussion with the Advisory Committee he decided on Alan Turing.

Turing provided the theoretical underpinnings for the modern computer. While best known for his work devising code-breaking machines during WWII, Turing played a pivotal role in the development of early computers first at the National Physical Laboratory and later at the University of Manchester. He set the foundations for work on artificial intelligence by considering the question of whether machines could think.

His legacy is all around us today. Computers form an integral part of modern life, from the way we work, to how we communicate and how we shop. But the concept of a universal machine that could solve all computable problems, was down to Turing.

Yesterday we released the main images that will be used on the Turing £50 note. Alongside his portrait, we have sought to represent Turing's work and accomplishments in the design. It includes technical drawings of the Bombe, which Turing worked on at Bletchley Park, and was instrumental in decoding enigma messages.

There is also a table and mathematical formulae from Turing's seminal 1936 paper "On Computable Numbers, with an application to the Entscheidungsproblem".¹ This paper is widely recognised as being foundational for computer science. It sought to establish whether there could be a definitive method by which any theorem could be assessed as provable or not using a universal machine. It introduced the concept of a Turing machine as a thought experiment of how computers could operate. This fed instructions through symbols on an infinite piece of tape. At the time it was an abstract concept, but it recognisably embodies the core principles of a modern computer and the logic of binary code. The binary on the ticker tape on the note depicts Alan Turing's birthday – 23 June 1912.

You can also see the Automatic Computing Engine (ACE) Pilot Machine which was developed at the National Physical Laboratory as the trial model of Turing's pioneering ACE design. The ACE was one of the first electronic stored-program digital computers. Although the computer age had barely begun, Turing was able to conceive the potential for this new technology in the future. That's reflected in the quote that will appear on the note "This is only a foretaste of what is to come, and only the shadow of what is going to be."

It is Turing's incredible scientific achievements that are reflected in the design, and the reason he was chosen to appear on the £50 note. But I am also very proud that Turing will be the first gay man to be depicted on a Bank of England note. This fact is all the more poignant given the horrific treatment Turing received as a result of his sexual orientation. In 1952, Turing was convicted of Gross Indecency for his relationship with a man. To avoid a prison sentence, he accepted probation which was conditional on receiving oestrogen hormone, otherwise known as 'chemical castration'. After his prosecution, he was no longer able to consult with GCHQ as homosexuals were ineligible for security clearance. In 2009, Gordon Brown made an official posthumous apology for Turing's treatment, and Turing received a royal pardon for the conviction in December 2013. In 2017, the 'Alan Turing Law', was passed that posthumously pardoned men cautioned or convicted under historical legislation that outlawed homosexual acts.

I hope that Turing's depiction on the note will serve as a reminder to all of us of that prejudice has no place in the UK today whatever guise it comes in. Everyone's achievements deserve to be celebrated, no matter their personal characteristics.

¹ Proceedings of the London Mathematical Society

We expect that the new £50 note will enter circulation by the end of 2021.

The note comes at a time when the computers that Turing made possible are rapidly changing the world around us. Science and technological advances continue to have an impact on how we make payments. Digital currencies, cashless technology and other payment evolutions are rapidly changing how we use and perceive money - perhaps more quickly than at any time since money was created.

Cash transactions in UK have declined from 61% of all transactions in 2007 to 28% in 2018 with over 5 million adults living almost entirely cashlessly.² And the trend looks set to continue with the latest forecasts suggesting the proportion of cash transactions will fall to 9% by 2028.³

Whether these forecasts are borne out will depend on a range of factors including further technological change, government policy and importantly consumer preference. But while the media often talk about the imminent move to a cashless society, the reality is rather different. 1.3 million people in the UK do not have a bank account⁴ and around 2 million adults rely predominantly on cash for everyday spending.⁵ Many of these people have low incomes and prefer cash for simpler budgeting. But many more choose to use cash for some or all of their payments for other reasons; perhaps because they find it more widely accepted where they shop, because they like the increased privacy or because it is what they are used to.

The Bank of England's role is not to promote one form of payment over another. We produce and issue our banknotes but we also settle £600 billion worth of electronic payments every day. Our role is to ensure that people have the choice to pay in the way that they want to. There are still billions of cash payments every year and millions of people relying on cash for their everyday spending.

That is why the Bank is committed to cash. I think we are looking at moving to a less cash society rather than a cashless one – at least for the foreseeable future. And as long as people still want to use notes it is my job to ensure that they have notes they can use with confidence and science will continue to help us in doing this.

But we can't ignore the fact that the computer revolution – which started with Turing – is continuing apace. And while I'm confident there will be a role for cash for many years to come, that role will be alongside an increasing range of digital payment options. Just as we have with cash, the Bank will need to stay abreast of innovation and technological developments in this space in order to continue to meet its objectives of maintaining monetary and financial stability. It may turn out that Turing's quote that will appear on the note will turn out to be as prophetic in the payments space as it was in relation to computing, and that what we see today is "only a foretaste of what is to come and only the shadow of what is going to be."

² UK Finance (2019)

³ Ibid

⁴ Financial Conduct Authority (2018)

⁵ UK Finance (2019)

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