During the early years of the eighteenth century the accurate determination of longitude at sea was a very pressing concern, particularly acute for a maritime nation like Great Britain. A number of shipwrecks and the associated loss of life were directly attributable to mistakes in the computation of longitude and aside from high-profile major disasters the difficulties in navigation caused by the inability to accurately determine one’s position led to longer voyages which in turn led to greater risk of scurvy and other illnesses which afflicted the sailors of the age. The impact on trade was also significant and many fortunes were ruined for want of a solution to this basic problem of navigation.

The clamour for a workable solution was heeded and on 8 July 1714 the British parliament issued the Longitude Act. A huge prize was offered: £20,000 for a practicable solution which would lead to the determination of longitude to within half a degree (30 nautical miles at the equator), £15,000 if the accuracy was 2/3 of a degree and £10,000 if one degree accuracy was achieved. Estimates vary, but £20,000 in 1714 is almost certainly worth more than £2 million in today’s money.

As is now well known, thanks in significant part to the popular book on the subject by Dava Sobel, the problem was eventually solved by the development of an accurate marine chronometer by the Yorkshire clockmaker John Harrison who was (eventually) awarded £15,000 of the prize money. Chronometers were, however, prohibitively expensive and the use of lunar tables was also worked on extensively throughout the 1700s and remained the most common method for determining longitude until the 19th century. The challenge of producing accurate lunar tables was in turn a mathematical problem to which many contributed, not least Isaac Newton who first published a lunar theory in 1702.

Revised versions appeared in the second and third editions of the Principia, where Newton provided an algorithm for computing the moon’s position which was clearly designed as a predictive tool rather than a theoretical derivation of the consequences of gravitation. Newton did attempt to show how gravity could cause the various corrections he applied to the lunar motion, but his real aim, as the preface to the original version made clear, was to produce a method which would determine the moon’s position sufficiently accurately to be of use in finding longitude at sea.

When Newton began his work on the lunar theory, he hoped that he would be able to quantitatively explain the moon’s motion using the theory of gravitation. He became increasingly frustrated, however, with his inability to produce an accurate mathematical theory. Eventually he was persuaded, largely by the first Astronomer Royal John Flamsteed, that the best approach was to build on an earlier theory of Jeremiah Horrocks based on a continually varying Keplerian ellipse. To Horrocks’ mechanism, Newton added a number of small sinusoidal oscillations so as to better fit the observations. He ended up with seven equations of lunar motion, where in this context the word equation refers to an angle that must be added to or subtracted from a mean motion so as to account for a particular feature of an orbit. The first two of these modifications accounted for the equation of centre (reflecting the fact that the earth is not at the centre of the moon’s orbit) and the ejection (which linked the motion of the moon to that of the sun), both known to the Greeks.

Two of the other equations accounted for phenomena known as the variation and the annual equation, both of which had been discovered by Tycho Brahe, although it was Newton who correctly identified the causes as being due to secondary effects of the sun’s perturbative influence on the moon. The remaining four steps in Newton’s algorithm were entirely new and were to some extent ad hoc corrections to make the scheme work better. In order to use the procedure the moon’s position thus had to be adjusted (‘equated’) seven times, and then, as Newton proudly stated, ‘this is her place in her proper orbit’.

Newton’s work was controversial at the time and certainly not accurate enough to be a contender for the Longitude prize. Better lunar theories were developed by men such as Clairaut, Euler and D’Alembert, with Euler securing £300 of the prize money for his theoretical work which helped Tobias Mayer to produce, in 1753, the first set of lunar tables that were of sufficient accuracy for them to be of practical use in longitude determination. Mayer was awarded £3,000 for his efforts, but did not live to benefit from the money due to his untimely death aged 39.

Fast forward 300 years. What are the great challenges of our time and how might we solve them? The 1714 Longitude Act set up a Board of Longitude, representing the great and the good, to judge solutions and a number of organisations have got together in 2014 to run a new competition, capturing the spirit of the original (see www.longitudeprize.org). The Longitude Committee, chaired by Lord Martin Rees the Astronomer Royal, deliberated and consulted over a number of months and came up with six big issues and then invited the public to vote for the one they felt was the most important challenge facing humanity. In passing I will note that this group was made up of 18 people with a broad spectrum of expertise, but no mathematician among them – yet another example, if one were needed, that mathematicians are not considered relevant by some to the problems of the future. The six issues shortlisted were: Antibiotics (How can we prevent the rise of resistance to antibiotics?), Dementia (How can we help people with dementia live independently for longer?), Flight (How can we fly without damaging the environment?), Food (How can we ensure everyone has nutritious, sustainable food?), Paralysis (How can we restore movement to those with paralysis?), and Water (How can we ensure everyone can have access to safe and clean water?).

One of the most obvious comments to make about this list is that two fundamental topics underpin all the issues – health and sustainability. Nothing about global communications, the internet, and associated governance, nothing about the development of new materials for all sorts of applications, nothing about robotics and automation, nothing about renewable energy, nothing about quantum technology. Notwithstanding this rather narrow focus, and also the observation that the causes of some of the problems for which solutions are sought are largely our past successes in prolonging people’s lives, the challenges are certainly highly relevant and important; for what it’s worth my vote went to Water. The result of the public vote was announced on 25 June and the winning challenge is antibiotics. In more detail: ‘The development of antibiotics has added an average... £20,000 for a practicable solution which would lead to the determination of longitude to within half a degree ...
of 20 years to our life. Yet the rise of antimicrobial resistance is threatening to make them ineffective. This poses a significant future risk as common infections become untreatable. The challenge is to create a cost-effective, accurate, rapid, and easy-to-use test for bacterial infections that will allow health professionals worldwide to administer the right antibiotics at the right time. In the spirit of the original challenge there should be a significant prize, and there is. The criteria against which everyone will be judged, amateurs and professionals alike, are due to be unveiled in the autumn and then people will have up to five years to solve the challenge, which carries a £10 million prize!

What, if anything, does all this say about the importance of mathematics in solving the problems of tomorrow? The Antibiotics Challenge doesn’t seem to offer much scope for mathematical contributions (though maybe statistics has a role to play as an underpinning for epidemiology) and although there are clear areas within the other five shortlisted challenges that might be fruitful territory for mathematicians there isn’t a great deal to latch on to. At first sight this might appear somewhat disheartening, but I think there is reason for optimism. As we know, applications of mathematics are often unforeseen and come from surprising corners of the discipline. If in 20 years we look back at the solutions that have been found for the six challenges I am sure that we will see the hand of mathematicians at work. But opportunities will be missed if mathematicians are ignored in the development of programmes around these themes and also if we as mathematicians choose to ignore what others think are the most important challenges that we face.

Chris Linton FIMA

© Artistashmita | Dreamstime.com

Would you like to contribute to Mathematics Today?

The Mathematics Today Editorial Board is looking for new members. At present we would particularly encourage Candidates to represent widening participation (youth, female, non-Caucasian). The IMA Membership Taskforce report, which has been approved by Council, includes a ‘gender aspiration’ that ideally, in any IMA gathering, there should be no more than 75% of any one gender.

The Editorial Board guide the production of Mathematics Today and meet twice a year in London.

If you would like to apply become a member of the Mathematics Today Editorial Board, please submit your CV and a brief statement outlining what you believe you can bring to the Editorial Board to Rebecca Waters, Editorial Officer (rebecca.waters@ima.org.uk), by 10 September 2014.

IMA Councillor Wins Rooke Award

Congratulations to Dr Diane Crann MIMA, Clothworkers’ Fellow in Mathematics and Masterclass Programme Manager at the Ri, who won the 2014 prestigious Rooke Award of the Royal Academy of Engineering.

This award, which highlights excellence in public engagement, has been given to Diane in recognition of her pivotal role in setting up a national programme of Ri Engineering Masterclasses for young people. The aim of these hands-on sessions is to open the eyes of young people to the excitement and value of engineering, and the diverse range of careers it can offer, by encouraging them to think creatively about solving real-life problems.

On winning the award, Dr Crann said: ‘I am thrilled to be named the recipient of this year’s Rooke Award. It has been an honour to lead the Ri Masterclasses team and support so many fantastic engineers to share their passion for the subject with the next generation. I hope that many young people will now pursue engineering as a career as a result of their fun and inspiring sessions and that is something we should all be incredibly proud of.’

Chair of the Awards Committee Dervilla Mitchell FREng said: ‘Diane has invested great amounts of energy into setting up a programme of dedicated masterclasses in engineering at the Royal Institution. Her passion and enthusiasm for the subject is evident and her dedication to spreading the excitement of engineering is to be highly applauded. In awarding Diane this year’s Rooke Award, we are recognising her long-term contribution and commitment to engineering engagement and education which will have a long-lasting legacy at the Ri.’

Director of Science and Education at the Royal Institution Dr Gail Cardew said: ‘When I found out nominations for this year’s Rooke Award had opened, it took me about a nanosecond to decide to put Diane forward. I’ve been working with her for years and so I personally know how determined she has been to establish the Ri Engineering Masterclasses. Of course her expert knowledge in developing stimulating masterclasses for students played a huge part in this, but equally important is how she has assembled a powerful network of funders, teachers and of course engineers to pull it off.’

The Rooke Award for the public promotion of engineering is awarded to an individual, small team or organisation who promotes engineering to the public. The award is named in honour of the late Sir Denis Rooke OM CBE FRS FREng, a former President of the Royal Academy of Engineering and one of the UK’s most distinguished engineers.

For further information see www.raeng.org.uk/prizes/rooke/default.htm and www.rigb.org/about/news/summer-2014/rooke