

DOWN TO EARTH: A SOLUTION TO A GLOBAL PROBLEM?

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The influence of space technology is pervasive in every day life. As, Vladimir Putkov stated at the last UNIDIR outer space conference, “People no longer can do without telecommunications, navigation and the information provided by remote sensing based on space systems”.

I would like to talk to you about our work in translating technology, that was originally developed to search for life in our solar system, to the provision of a potential solution for one of the greatest healthcare challenges facing the human race at present—the early detection and subsequent treatment of tuberculosis (TB).

Let me start by explaining a bit about the Planetary and Space Sciences Research Institute, better known as PSSRI, the largest planetary sciences group in the United Kingdom. We are based at The Open University, in Milton Keynes, just north of London. The Open University is one of the largest universities in Europe, with over 220,000 distance-learning undergraduates registered—that is 5% of the United Kingdom’s undergraduate population.

The institute is home to over 60 multi-disciplinary staff and we are very fortunate to be housed in a state-of-the art building with world class laboratory and clean room facilities. Indeed, some of our instruments are unique in the United Kingdom—one example is the CAMECA NanoSIMS 50L mass spectrometer, which cost £2 million and is currently being used to analyse interstellar dust samples returned by the US National Aeronautics and Space Administration’s Stardust mission. As the above project would suggest, the group specializes in developing instrumentation for the analysis of extra-terrestrial samples in the laboratory; instruments are also developed for *in situ* analysis on space missions.

We have been involved in providing instruments, or support, to over 10 missions so far, from Prof. Colin Pillinger’s analysis of the Apollo XI samples to having experiments on the most recent Space Shuttle mission.

Other missions in which the group has had significant involvement include Giotto, Cassini–Huygens, Stardust, Genesis and Flying Stones. The mission of most relevance to this presentation is the European Space Agency’s Rosetta mission. Launched on 2 March 2004, it is currently on a four billion mile, 10-year journey around the solar system, chasing comet Churyumov Gerasimenko. In March 2014, at a distance 3.5 times the distance the Earth is from the Sun, we hope to catch up with the comet. The orbiter craft will then spend six months mapping and analysing the chemical composition of the nucleus before depositing the Philae lander for the first ever soft landing on a cometary nucleus.

We have an instrument on the Philae lander and we intend, with the help of Italian, German and French systems, to analyse the composition of the comet, to answer fundamental questions such as did water on Earth come from a cometary impact early in history? Did the building blocks of life arrive at the same time?

The instrument we have built to conduct these analyses is known as Ptolemy. Ptolemy is a miniature Gas Chromatograph–Isotope Ratio–Mass Spectrometer that weighs just over 4kg and is about the same size as a shoe box. Ptolemy was developed in partnership with our colleagues at the Rutherford Appleton Laboratory, with approximately £7 million of funding from the Science and Technology Facilities Council.

However, the mission we are most famous for is the Beagle 2 Mars lander. The *raison d’être* for the Beagle 2 mission was this instrument—the Gas Analysis Package. The package was a miniaturized version of the instruments used in the laboratory to analyse meteorites and was designed to determine whether conditions were ever conducive to life on Mars.

Unfortunately, all contact with Beagle 2 was lost. We have no telemetry from Beagle 2 after it was released from the Express Orbiter on 19 December 2003 and we cannot therefore be certain of the exact nature of the failure. One consolation was that the Mars Express Orbiter went on to have a highly successful mission and has been sending back fantastic scientific data ever since.

The development of the Gas Analysis Package instrument was mainly funded by the Wellcome Trust, the world’s largest medical research charity. Prof. Pilling had persuaded them that the technology being developed to search

for life on Mars could have a number of potential applications for global healthcare. With Prof. Pillinger involved with the inevitable postmortem of the Beagle 2 mission, I took over as the Research Director for this the second phase of the project. The remit was: “Explore all possible opportunities to investigate technology transfer to clinical or medical applications”.

Initial investigations concentrated on the rapidly developing area of breath analysis for the diagnosis of medical conditions. At the time, it was concluded that the field was still too immature for an instrument to be designed for any specific disease. It was at this point that the Trust indicated that they would be highly interested in a rapid diagnostic test for TB.

Tuberculosis is an airborne disease caused by *Mycobacterium tuberculosis*. The disease is rapidly spread by being in close contact with an infected person who is coughing or sneezing. The global scale of the problem is illustrated by figures released by the World Health Organization for 2003. They estimated the following number of cases:

- latent TB (non-active): 2 billion;
- prevalence (existing cases): 14.6 million;
- incidence (new cases): 8.8 million; and
- mortality (deaths): 1.7 million.

In addition, the World Health Organization’s Stop TB Department has reported that there has been a significant increase in the incidence rates of TB since 1990, especially in the developing world. The increases in sub-Saharan Africa have been particularly pronounced, for example the reported incidence rate in Swaziland in 2005 was 1,262 cases per 100,000 people.

A major contributing factor for the rise in the incidence of TB in sub-Saharan Africa is co-infection with HIV. TB is now the most common cause of death in Africa among those infected with HIV, and it has been reported that in Southern Africa about half of all deaths from TB are being diagnosed during autopsy, not while the patient was alive.

TB diagnosis in resource-poor settings relies primarily on smear microscopy. This is a highly inaccurate technique and requires an operator to make a decision on the presence of the bacteria. It is estimated that smear microscopy will only diagnose 3 out of every 10 TB-positive patients presenting

themselves at a clinic—the remainder must undergo a process that can result in them having to return up to 10 times before being diagnosed. The gold-standard method for the diagnosis of TB is the preparation of a culture, followed by microscopy. Unfortunately, as TB grows so slowly this can take up to six weeks. In addition, because of the infrastructure required, it is only available in a few laboratories in each country in the developing world. It is clear that there is a need for a rapid and sensitive diagnostic technique that is appropriate for use in resource-poor settings.

Preliminary work, during the original Wellcome Trust project, suggested that a gas chromatograph–mass spectrometer-based technique could provide such a solution. As a result, I was invited to put together a consortium to bid for a Strategic Translation Award from the Trust. The consortium included Prof. Pillinger and Prof. Wright from The Open University; Dr. Elizabeth Corbett and Dr. Ruth McNerney from the London School of Hygiene and Tropical Medicine, and Dr. Conrad Bessant from Cranfield University.

Dr. Corbett is a clinical epidemiologist practicing at the Biomedical Research Training Institute in Harare. Dr. McNerney is a microbiologist based in London specializing in evaluating diagnostic tests for TB. Dr. Bessant is a bioinformatics specialist and will produce the algorithm that will determine the disease state from the compounds present. The Open University will provide the analytical chemistry for the diagnostic test and will also develop and build the gas chromatograph–mass spectrometer system.

The application was successful, and as a result the project has been funded for a period two years. The project started on 1 February 2008. The first 12 months has been split into two parallel phases. The first will concentrate on the development, optimization and validation of a suitable sampling and analytical technique. The second will produce several versions of the instrument. The ultimate goal of both phases is the development of an instrument and methodology that can be used at the Biomedical Research Training Institute, for a 12-month performance evaluation trial. It is during this trial that the sensitivity and selectivity of the newly developed process will be compared, in the field, with the existing diagnostic tests available.

I would like to finish the presentation with a quotation from Dr. Ted Bianco, Director of Technology Transfer at the Wellcome Trust:

Combining their expertise in mass spectrometry with the experience of doctors working in Southern Africa is a potent mix of talent. If you can build instruments rugged enough to look for life elsewhere in the Solar System, you should be able to crack the problem of detecting TB bacteria in the lung of a patient.

The Wellcome Trust has recognized the potential that space technology can have in providing new solutions to existing global healthcare issues. It also recognizes the importance of the interaction of the end-users with the technology developers. If this project is successful, I would hope that it opens the way to the funding of the translation of other space technologies to the global healthcare arena.