Feeling at home with your own genome

Prof Valerie Corfield, US/MRC Centre for Molecular and Cellular Biology, Faculty of Health Sciences, University of Stellenbosch, and Dr Wieland Gevers, UCT

Tertiary education centres are often seen as ivory towers, with science a lofty ideal, its pursuit and applications of no relevance to other members of society. Students graduating from the system and entering commerce and industry quickly acquire new applied knowledge specific to their field, and relegate other science and technology learnt to the recesses of their minds. Similarly, those teaching in primary and secondary schools must bow to the demands of the curriculum, and there is little room for non-curricular science. The graduate who re-enters the postgraduate system will climb back into the tower and throw away the key, for, traditionally, the role of the research scientist was to dedicate herself to arcane pursuits and that of her institution was to provide a nurturing environment for such endeavours. "*Publish or perish*" has long been the axiom of academia and success has been measured by the number of publications in high scoring peer reviewed journals, not by sharing her research and its broader scientific context with a public audience.

Thus, new developments and exciting cutting edge research are likely to be locked away, inaccessible to Joe and Josie Public and their children. Generally, the excitement of the forward march of science, of new discoveries and their applications become topics for University "journal club" and staff room discussion, and are unlikely to be playground chatter, boardroom speak, pub banter or dinner party conversation. New technologies that do stir public attention are often those that have been adopted by a press eager to boost readership by sensationalism, for example, Franken foods and the Boys from Brazil.

Early in the 1990s, scientists in Britain and America began to take a new look at their role in society and the responsibility of their institutions to encourage a bridging of the communication gap between science and society. It is fitting for the theme of this paper, the decoding of the human genome and its societal implications, that James Watson, who, with Francis Crick 50 years ago was the discover of the DNA double helix, pointed out "*...science is not done in a vacuum and should not be pursued as if it could be. Good science always affects social context, and the practical effects of good basic science are often the most wide-ranging of all*" (*Watson and Juengst 1992*). At the University of Washington, USA, Leroy Hood, another renowned molecular biologist asked faculty members to devote 5-10% of their time to outreach activities, as he himself did, in their case working with local school teachers "*in exposing kids to cutting edge science*" (*Science 1994a*). Meanwhile, in Britain, educators and scientists came up with a novel scheme to show that science is not limited to standing at a laboratory bench. A five year project was funded to place PhD "researchers in residence" in schools, where they worked with pupils and teachers in developing a new outlook on the role of science and technology in society (*Masood 1997*).

In South Africa, with its history of inequalities in education, the need to promote public awareness of science and its societal implications is particularly relevant. Here we confront many challenges, we are a culturally diverse society, speaking eleven official languages; we are in a state of transition, living in both the first and third world and we face widespread scientific illiteracy. Prior to 1994, science was in the domain of the privileged minority, science was isolated from society and science and scientists were not accountable to the people. However, post-transition, the new government has prioritised the democratisation of science and "*promoted the popularisation of science as a key driver of socioeconomic advancement*" (*Joubert 2001*). The Department of Arts, Culture, Science and Technology's clarion wakeup call is echoing in the corridors of the research councils and Universities. Their scientists can no longer isolate themselves in their ivory towers, they are being called to account by the South African government, its funding bodies (SAASTA, MRC, NRF) and by other funders, for example the British Wellcome Trust (www.wellcome.ac.uk) and they are required to effectively communicate the scientific context, the societal relevance, the impact and the applications of their research. It is recognised that novel approaches are needed to engage the public young or old, rich or poor- in an appreciation and understanding of science and technology (eg *A National Biotechnology Strategy for South Africa, 2001*) and, for the first time, grants are available and the call is out for scientists and science communicators to tackle this exciting new challenge (for example SAASTA/PUB; Wellcome Trust International Engagement Awards).

Putting the "wow!" factor into the physical and natural sciences, in the form of bangs and explosions or charismatic animals, is a sure way to engage the public and consequently these disciplines have generally outpaced the biomedical sciences in the competition to captivate a wider audience. Yet, undoubtedly, recent advances in molecular biology will have their greatest impact in human health and disease, and surveys have shown that people generally have a "healthy" interest in their physical well-being and illnesses. Understanding the DNA molecule, the architecture of the genome and the nature of inheritance are not esoteric pursuits. The completion of the Human Genome Project and the availability of a draft of the total sequence of human chromosomal DNA have widespread implications for science and society. Increasingly, DNA-based tests will form part of routine medical diagnostic and patient management strategies, and the results of these tests may impact not only on an individual's health insurance, life insurance and employment opportunities, but also affect other family members. DNA-based forensic evidence is presented during cases of murder and rape and in paternity disputes, the victim, the accused, the judiciary, lawyers, doctors and the police have a vested interest in understanding the technology being applied.

Furthermore, of special relevance to South Africa with its rich diversity of peoples, is that the information encoded in the genomes of cultural isolates provides a rich resource for molecular studies. These include investigations of the origins and dispersions of man and also the development of drugs to treat many of the ailments of the modern world. These investigations can only be considered to have met ethical standards if the peoples involved have truly given *informed* consent. To do this, they need to understand the nature of genetic information, their genomic individuality and the genetic ties to their family and their community.

A new imperative is emerging in the hallowed halls of South African academia, namely, "*publicise, publish or perish*" and I will describe my experiences as a molecular biologist of communicating science to very diverse audiences. I use a workshop that I developed to engage public interest and understanding of developments in human genome science, and their applications, as a case study to illustrate this, and highlight the lessons learnt in this endeavour.

The idea of the workshop was born from my interest in DNA and the Human Genome Project, a combination of my research focus and my scientific hobby. Consequently, when I was asked by the South African Medical Research Council (MRC) to take part in a joint Research Councils' outreach contribution at the 2000 Grahamstown Scifest, I decided to design a workshop emphasising the applications of DNA technology. My aim was to make it a hands-on, interactive and stimulating activity that demystified and "dejargonised" the concepts of DNA and inheritance, while spotlighting the Human Genome Initiative and its applications in forensic science. I also wanted to make the workshop suitable for presentation to a wide range of audiences, at any venue and using easily obtainable, low cost materials, so that biology teachers could run similar activities in their own classrooms. As a result of the first Grahamstown workshop, I have been invited to present it annually at this venue, and I have run one or two workshops a day for seven days every year from 2001-2010 (in addition to other workshops that I have developed on food science, enzymes, drug abuse and HIV/AIDS, the latter in collaboration with a colleague, Dr Francois Cilliers). These workshops have all been sponsored by the MRC, which is committed to promoting an understanding and appreciation of science, particularly biomedicine, to the general public.

To engage school learners' interest in particular, I entitled the workshop "T*he DNA detective: what's in your genes*" and advertised it as an opportunity to "prepare DNA, check out your genes, explore the genetic code, then break the rules of this code and find out what happens. See why everyone looks like their moms and dads, brothers and sisters, yet is not exactly the same. Play detective and investigate how DNA is used to solve gruesome crimes and old mysteries".

Gradually, more teachers and special interest groups heard about the "*the DNA detective: what's in your genes*" and I have been asked to present it on many occasions, under many different circumstances- some quite challenging! I soon learnt to think on my feet and be flexible; thus, workshops can be run from one hour to four hours, and do not need the participants to have even heard of DNA.

Teachers could run similar activities in their own classrooms. As a result of the first Grahamstown workshop, I have been invited to present it annually at this venue, and I have run one or two workshops a day for seven days every year from 2001-2010 (in addition to other workshops that I have developed on food science, enzymes, drug abuse and HIV/AIDS, the latter in collaboration with a colleague, Dr Francois Cilliers). These workshops have all been sponsored by the MRC, which is committed to promoting an understanding and appreciation of science, particularly biomedicine, to the general public.

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In this iterative process, I have learnt many lessons and I have continued to incorporate them into the presentations. To engage *participants*, it is vital that they indeed *participate*! This is especially true with school children, most of who will switch off their concentration, as soon as they catch a whiff that any "workshop" is just another school lesson. Very important too has been to design flexible modules, so that the workshop can be presented under very different circumstances, to very different audiences. Also significant has been to use inexpensive and easily available materials, many school classes are large, finding continued sponsorship is time consuming and teachers attending are more likely to use the workshop in their own classrooms if they can do so easily.

It is also important when *engaging* the public to indeed *engage* them! Here, I try to use my imagination so that concepts can be visualized, and although everything said must be scientifically accurate, it is vital not to get bogged down in minutia. Thus, I use a cell phone instruction manual to represent a genome and a two metre spiral telephone cord to represent the length of DNA unravelling from one cell. I wear one red and one blue shoe to represent a homologous chromosome pair and the process of meiosis.

Introducing the "wow!" factor cannot be over-emphasised the sight of clouds of fluffy DNA strands swirling out of a preparation in the participant's hands never ceases to amaze. People do not enjoy sitting on a very uncomfortable chair for up to 90 minutes, so I include alternate sitting and moving activities; for example, building a mini-protein out of Lego blocks from the "cytoplasm" in the centre of the venue, using an "RNA" message that they have written and decoded. School learners are always enlivened by an element of competition, so the person who builds their protein first can be viewed as a cell with the fastest metabolism.

I have involved a lot of teachers through the Primary Science Programme. The HIV workshops are very popular with teachers and many attend. But they're nervous to do it for themselves. My own idea has been to at least get some money to make some kits, and then workshop with the teachers and give them the kits, so they've got something in their hands. They appreciate what we might call spoon-feeding, but, they have not had education in biology, and they don't want to tell the learners the wrong thing. And I've tried to give ownership of it to the community liaison officer at the MRC, Khalipha Ramahlape, who is a previous high school teacher, and she's been involved in running these workshops as well.

Molecular biology is a metaphoric science, even the *cognoscenti* use metaphor to capture a view of molecules and events that they cannot visualise directly. However, when engaging the culturally diverse South African public, it is important to use appropriate metaphors, the spiral stairway that is the icon of DNA science may not be relevant to those living in informal settlements. Similarly, when engaging the public in the ethical, legal and societal implications of the human genome project, it helps to use pertinent applications and examples. As so many in our society are the victims of violent crime and rape, and as traditional family structures change, I have found young and old participants fascinated by the use of genomic information and DNA technology in forensic science and paternity testing.

Although one measure of the success of the DNA workshop has been an ever-increasing number of requests to present it, formal evaluation has been constructive (Ramahlape et al 2002). In a pilot study, a questionnaire to evaluate the impact of the workshop on participants' knowledge of DNA science, the human genome project and its societal relevance was applied. The workshop was presented five times, once to learners from the Cape Town International School, twice to teachers from under-resourced primary schools in the Cape Peninsula, once to grade 11 learners from previously disadvantaged communities already selected for an enrichment science and maths programme (COSAT) and once to grade 10 learners being recruited for the COSAT programme. On average, the participants performed better after the test than before, although a breakdown in the scores revealed that a disappointing number of learners in the recruitment group scored a lower mark after the test. Examination of the questions in which the learners faired badly suggested that in two cases, specifically involving the goals of the genome project, the switch from right to wrong answer could have been due the presenter stressing the application of DNA technology to solving crime, this in turn being relevant in the South African context and being one of the themes of the workshop. The other two incorrect answers were more directly related to scientific confusion about the differences between nucleotides, amino acids and the triplet code. In all cases, the importance of the way in which science is communicated and the value of formal evaluation were evident and have been earmarked for attention.

The open-ended section of a separate feedback questionnaire administered to teachers was encouraging, with nearly half of respondents believing that they had learnt a lot and that the workshop was interesting, while 40% found enjoyed the "wow!" factor and valued societal relevance. Other comments included a desire to run similar workshops themselves and that although the activity was pitched at a level appropriate to the audience, more time was needed for explanations and discussion. Informal discourse and experience have highlighted the need for bilingual and/or home language presentations to target groups. The participants also face difficulties in getting to venues, for many different reasons, including transport reliability and costs, safety concerns in winter when darkness falls early, extra-curricular activities etc. This can also make it difficult for the presenter, as numbers expected can be unpredictable, and participants may arrive late and have to leave early.

A final challenge is to find the right people to give the workshops. Professor Mike Bruton of the MTN Science Centre says that presenters should be "*colourful, extreme extroverts, whacky, irreverent, larger than life*..." probably not the personality profile of the average South African scientist! Additionally, although South African Universities and research institutions are increasingly supporting outreach activities and recognise the need for individual scientists to develop this facet of their responsibilities, there is the justified concern among scientists that such efforts may harm their research careers. Time spent away from the laboratory is time taken from their responsibility to produce publishable research. Back in 1994, the University of Arizona became the first university in the United States to include outreach as one of the major criteria for tenure and promotion (*Science 1994b*). I believe that in South Africa more formal recognition still remains to be given to outreach activities, in the words of Khanna (2001), reporting on science communication in developing countries,

> "*a health researcher's job is not over until the research findings have been peer reviewed, published and transmitted to health policy makers and the general public*".

It is again appropriate to quote Watson, whose involvement in the discovery of the DNA double helix paved the way for the human genome initiative and continues to have far-reaching implications for mankind,

> "*...science and society can pull together to optimize the benefits of new knowledge for human welfare and opportunity*"

(*Watson and Juengst* 1992).

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