The 2016 Ralph Slatyer address on

“Science in Society”

Ian H Frazer AC FRS

This is an edited version of a talk presented to the Cooperative Research Centres Association Annual Meeting in Brisbane in March 2016

It is a great honour to be asked to give this address in Prof Slatyer’s name, and in the presence of his wife and daughter. Prof Ralph Slatyer AC FRS was Australia’s first Chief scientist, appointed to this role in 1989 after a distinguished career in agricultural science, ecology, and environmental biology. He was a leader in Science policy both within Australia and globally. In his role as Australian chief scientist, he defined to government the need for the Cooperative Research Centers, and the set the groundwork in place for their creation. He was a proponent of innovation, lobbying for R+D tax concessions, and his success as chief scientist has ensured the perpetuation of the position, currently occupied by Prof Alan Finkel and most recently by Prof Ian Chubb

It seems to me tautological to consider the role of science in society. The current densely populated planet that we live and work in could not exist without the products of science. We just need to consider the essential nature of the contribution to our modern world of clean water, sufficient food, power storage, efficient transport, electronic communication, golden rice to prevent blindness in the developing world, cancer drugs: the list is endless. Conversely, science could not exist without a supportive society: we as scientists have to remember that we are in effect icing on the societal cake or, put another way, parasites on the productive workforce. This dependency relationship gives us an obligation to repeatedly justify our existence to government. I suspect that some governments do regard us as an optional extra, the first to go when times are tough though fortunately Australia has to date taken a different view from many countries on this issue. Given Prof Slatyer's considerable efforts towards research translation and innovation, I think that he might be rather puzzled by the "new" push for innovation and commercialization in science, mooted recently within both state and federal governments as essential to our future economic growth. However, I think we can be confident that innovation, collaboration and commercialization will remain on the agenda for the foreseeable future, even though I have concerns as a bioscientist about the practicality of indefinitely sustained growth in a finite pool of resources!

The inseparability of the scientific process from societal and individual development was recognized 250 years ago by the Scottish philosopher David Hume, who tried to define a process of scientific thought, separate from human behavior, in his major work “A Treatise of Human Nature.” He didn’t meet with much success- partly because the book sold only 2 copies in his lifetime, in his own words ”it dropped still born from the press”. However, a very practical outcome for his efforts was the first true definition of the scientific process, which he described as one requiring demonstrated reproducibility of a phenomenon: this was necessary to distinguish the real world, from the miracles that were of interest at that time to the church, and which David Hume had little time for, despite being commissioned by the church to provide a working definition.

Given that science and society are inseparable, why then do we need continually to talk to society about the role of science in society. I suspect that it's a case of “familiarity breeds contempt” – society is always willing to embrace the products of science, but forgets pretty rapidly the contribution of scientific endeavour to their creation. Think mobile phones, wi-fi, vaccines, and fusion power (oops, we haven’t quite invented that yet, despite continued press rumours to the contrary, but given time we will). I believe that pretty much all innovation and scientific thinking, and resulting advances in technology, can be incorporated into our society and individual lives to ensure that we make a great place for our kids to live . However, people fear what they don’t understand. The benefits of science will be fully reaped only if advances in knowledge are backed by an increasingly science literate society.

To exemplify this, I will discuss two challenges that face society in the sphere of human health science. One, control of infectious diseases, relates to the difficulty of persuading society to learn from, and reap the benefit of, past research.
The second, demonstrating the challenge of ensuring that society considers the future consequence of current scientific research, stems from our ability to “know” our own genetic blueprint, and what we can predict from this about our individual and collective futures.

Firstly: infections: We live on average 25 years longer than 100 years ago, and almost all of that gain in longevity is due to control of infections through antibiotics and vaccines. However, bacteria and viruses breed much much faster than we do, and evolve ways of escaping the defences we have acquired genetically, as well as the ones we derive through scientific research and manufacture as antibiotics and antivirals. The spectrum of new infections has gone, within my professional lifetime, literally from A to Z – AIDS to Zikavirus – and every new pathogen, and new pathogenic variant, in between (Bird flu, Coronavirus, Dengue, Ebolavirus, Flaviviruses Hendra virus, …..Lyssavirus, …SARS, …West nile virus. Science does its bit, by identifying these new pathogens, mapping their spread, working out how they make us ill, and eventually coming up with vaccines.

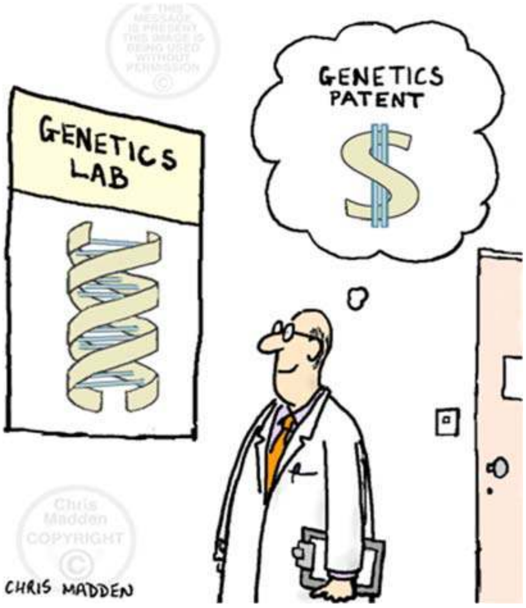
AUTISM CAUSES VACCINES.

Society, however, prefers to forget about the problem of infection until confronted with an epidemic. Antibiotics are abused for illnesses that they cannot control, and to produce higher food yields without best practice agriculture. Vaccines are at best, passively accepted (changed days from when people used to fight to get their kids to the front of the line for the newly invented poliovirus vaccines in the 1950s). Maintaining the immunization rate requires bribery, and then threats, from government. At worst, we have a number (but thankfully a small percentage) of people talking actively about the supposed dangers of vaccines (alum adjuvant as a deadly poison causing brain rot; boron preservative as a toxin, measles virus vaccine causing autism). By the way, given that autism spectrum disorders are over represented amongst scientists, we should turn the story around and remind the public that actually "autism causes vaccines". Beliefs that vaccines do no good, damaging the immune system, and it's better to get the infection can only be defeated with repeated pomulgation of the facts about what the illnesses that vaccines now prevent can actually do. The "inconvenient truth" is that vaccines, given to healthy individuals, may cause minor temporary symptomatology, but less than one in a million severe (usually anaphylactic) reactions, and occasional acceleration of presentation of disease that was going to occur anyway – usually immune function disorders. Fortunately for most of those who lobby against vaccines and (more significantly) for their children who are not given the chance of protection, herd immunity generally works. Wittingly or unwittingly those that do not vaccinate their children rely on the fact that vaccines given to communities break the chain of transmission of diseases that used to kill more children than survived to adult life. However, for the really infectious diseases, such as measles, herd immunity is difficult to attain, as 1 person can infect over 100 others, and if only 97 of those are immunized, then the disease will still spread epidemically amongst the unimmunized, and amongst those whom immunization hasn't or can't protect, as vaccines are not perfect and neither is our immune system. Measles is a lethal disease, with death or significant brain damage occurring in 1 in 1000 infected infants and young children. Mumps isn't all that much fun either with swollen glands, swollen testicles, and sterility, while polio kills about 1% of infected children, and leaves another 1% permanently paralyzed. Further, herd immunity isn't very much use for our kids when they travel abroad as young adults: HPV infection is not very infectious , and as a consequence is on the way out in Australia as a cause of genital warts, which have virtually disappeared in the under 30 population with only 35% of the population immunsed, and of the pap smear abnormalities leading to cervical cancer. However, HPV infection still pretty prevalent in south east Asia, and genital warts are now, amongst the young in Australia, largely a disease caught by travelling.

So, should we make vaccination compulsory in the interests of community health and the economy? Should we as a nation be doing more to persuade our government that investing in vaccine technology, vaccine education, and in their global use, would not only be humane, but also in our longer term economic self interest?

I would argue yes in public on both grounds: it will be a bit late to start up the industry, if the next strain of flu, coronavirus, or flavivirus spreads rapidly and kills 50% of those it infects. The real challenge is to make sure that we are continuously ready to deal with the new infections as they arise to threaten us: both the knowledge base and the physical infrastructure for vaccine production must be kept “state of the art “ on a global basis.

Let’s now switch to my second topic and consider the interaction between science and society that the genetic revolution has sparked. Genetic engineering has sparked controversy over genetically modified crops and animals , forgetting that we’ve been genetically modifying them through interbreeding for many hundreds of years, to the benefit of food production and therefore of society across the globe. This distrust of genetically modified foodstuffs, whether by breeding or engineering, demonstrates clearly that society is ill prepared for what is to come in the human genetic revolution.



Mendel worked out the practical basics of heritability 165 years ago. The molecular basis of heritability as self reproducing complex sugar polymers was defined 65 years ago by Crick, Watson, and colleagues. The ability to sequence complex genomes is 15 years old, and we have progressed from a $3 billion price tag for the first one to ability to do it for an individual for under $1000 in 3 days with "X10 " technology. The availability of this information however creates problems, as we don't really know how to use it yet, let alone to explain the benefits and limitations to the health profession and the community. Our ability to get sequencing data reliably correct is still a bit in the future, and the knowledge of what it means is patchy.

Industry is nevertheless ready to capitalize on the testing, and to screen humangenetic information and sell predictions based on the results. The requirement for a valid screening test is that the test itself should be accurate, there should be data to support utility and evaluate its practical predictive value, and a valid intervention that flows from the findings of the test should be available. The impact of genetics on society will be determined by our ability to handle the information sensibly, and this I suspect is still far in the future, for a range of reasons.

Consider the following scenario: I decide to have my DNA sequenced (as it happens, I've had this done, but I'm not ready to tell you quite what was found). Lets assume that it shows up no significant predictors of problems for my health , a relatively safe prediction as I've reached the age of 64 without disaster.   However, I have been demonstrated to carry six single copy recessive gene defects, which are harmless for me because I have one good and one faulty copy of the gene. This would be somewhat below average number of such defects, as current the estimate is that most people would have rather more, mostly as spontaneous new mutations. My kids have a 1 in 2 chance of inheriting any of these single gene defects : again no risk to them so long as their mother doesn't have the same problem gene. For 5 of these, the rare ones, seen in less than 1 in 10000 individuals, this is highly unlikely, which is just as well as nothing can be done about the lethal disease that would occur in one in 4 of our children if she did have the same gene defect. However, one variant gene I have, a gene which predisposes to iron storage problems, is actually a common variant, as 1: 30 people have it in Scotland, and so there's a reasonable chance that my wife might have it, and therefore my kids would have a one in 4 chance of getting the disorder. The iron storage disorder, if left untreated can lead to premature death from liver failure, or cancer. So, surely we should eradicate this defective gene!? The answer however is "Not really", because one copy of the abnormal gene will protect my partner against anemia due to menstrual blood loss, giving her a better chance of surviving into old age and rearing my children well. So let's keep it: However, potentially I'll get into trouble, as my bank manager and insurance agent, not to mention my employer, will all be interested in my proneness to ill health and early death because of the gene and its interaction with alcohol to produce liver disease.

And that's just the complexities around managing one gene defect- we have 30,000 genes and millions of variations in these, determining, through interactions, everything from intelligence to eye colour, sexual preference to sociopathic behavior : all the inherent variability that characterizes an outbred human race. So, do we really want to know our genetic makeup: well, yes to a degree Our genes predict, for example, whether we are likely to get diabetes if we get overweight, which might improve our chances of adopting behavior to avoid overweight, knowing the inherent risks. It can predict whether we will have a nasty allergic reaction to some drugs, and whether other drugs will be effective in treating , for example, high blood pressure. And it predicts some part of our risk of some common cancers.

Just to complicate things further, we could be given our genetic code at birth for no more than we currently spend on testing all newborn babies for some common treatable genetic disorders (eg congenital hypothyroidism) and the genetic code test would replace these existing screening tests. So it would be cost effective to learn everyone's genetic code at birth. Society has not yet caught up with this, and educating people, or even a select group of non-scientists, as "trust me I'm a scientist" doesn't work in this case, to understand the plusses and minuses of making the knowledge available will be hard.

And then there's the future, and a process called CRISP/R which allows safe, efficient, and reasonably accurate, editing of individual human genomes, and, potentially, germ line transmission of the changes from one generation to the next. This could be seen as scary stuff by the general public, especially as its already being used in animal husbandry to alter the genome of food animals, safely and to good purpose, by companies like Dr. Scott Fahrenkrug's Recombinetics, Inc.

Shortly, the pressure will be on to use it in humans: correcting heritable bleeding disorders like Hemophilia, and cystic fibrosis. However, it would in the future give us the potential to produce "designer babies", though fortunately most traits that people might choose for their kids (intelligence, appearance, behaviour) are determined by so many individual genes that it would be impractical, and there would be considerable potential for an adverse outcome due to unexpected gene interactions so high that people will not wish to experiment. Nevertheless, I feel that we've a lot of education to do before society as the hand that feeds us is ready for what we could give them in return.

So what can we take home from these two examples of potential friction at the interface of science and society.

1) We need good public advocates for, and against, the new sciences to ensure that informed debate can occur, before decisions are made that impact on society
2) We need a scientifically literate community to understand what is being discussed, and to debate the opinions of experts on what should be done to benefit the community
3) We need to recognize that commercial interests and societal interests can overlap but may not always do so, and that we may in consequence need proactive regulation of the use of new technologies.
4) We need an ongoing and well funded program of innovative basic science to keep the translational component of the system working for the good of society, and to be ready for the next challenges when they, as inevitably they will, turn up on our doorstep, to avoid surprises and disasters.