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Building foundations for an open perspective on synthetic biology research and innovation.

Jenni Rant[1] & Joyce Tait[2]

Authors:
Dr Jenni Rant[1*]
The SAW Trust,
John Innes Centre,
Norwich Research Park,
Norwich,
Norfolk NR4 7UH.

Professor Joyce Tait[2]
ESRC Innogen Centre,
University of Edinburgh,
Old Surgeons Hall,
High School Yards,
Edinburgh EH1 1LZ

***Correspondence:** jenni.rant@jic.ac.uk +44 1603 450465

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Introduction

Most present day scientists are extremely specialised in their respective fields and hard-wired into a peer review system that forms an integral part of research. Regulations to limit negative impacts of their research together with guidelines to ensure that research is carried out ethically are pervasive. Scientists collaborate on projects that bring complementary expertise together and are well equipped to share factual, accurate and relevant accounts of their research within the scientific community. The global communication network, increasingly driven by social media, enables the latest findings in research to be shared at an almost synaptic speed with recipients who perceive this knowledge in diverse ways. One could assume that the translation of research into a language accessible to a broad audience would be easy, contributing to maintaining informed public assessment of research and innovation, and also encouraging a more general interest in science as part of society. However, the reality has been patchy communication that is often reactive, triggered by recent developments and potential negative publicity rather than carefully considered proactive engagement. The recent measles outbreak serves as a powerful example of how messages from a single scientific paper published in 1998 caused a ripple effect leading to public concern, reduced uptake of vaccination and a general mistrust of scientists and government organisations. The paper has since been retracted (Wakefield *et al.* 1998; The Lancet, 2010) but the implications demonstrate how society processes, disseminates and reacts to information. When a new area of scientific advancement emerges from basic research, communication in a wide variety of forms will be key to framing that technology in the minds of members of the public, affecting market potential and the regulatory systems derived through the political process. Restrictions imposed by the UK government in 2004 for the cultivation of a herbicide-resistant maize variety were deemed too unfavourable for economic viability even after Farm Scale Evaluation trials showed that it caused less damage to wildlife than conventional varieties (Mason, 2004). In Europe discussions on the future governance of new technologies such as synthetic biology frequently refer to the GM crop experience, where negative public framing of GM technology, driven by a pressure group campaign with uncritical media support, has proven very resistant to change, despite strong and consistent evidence of the benefits of GM crops and their relative safety compared to the pesticides they replace. The prospect of another polarised public debate of the type that has surrounded GM crops had already convinced policy-makers and scientists to pay early attention to public dialogue on synthetic biology (Bhattachary *et al.*, 2010). Communication processes that are balanced and evidence-based will be increasingly important in the framing of new technologies or the re-framing of existing ones.

Investing in engagement – prevention instead of cure

Good public engagement seeks to encourage individuals to be interested in science, but also to be sufficiently informed and confident to consider research topics from their own perspectives. Introducing upcoming scientific advances to very young people may offer an effective way to ensure that the adult populations of the future are not alarmed by press releases about new technologies that have the potential to impact on their lives and that they are able to consider the likely pros and cons of the technology in an informed and reasoned way. A large proportion of engagement between researchers and young people occurs through the education system and has traditionally been targeted at secondary school, A-Level and undergraduate students. While this is a worthwhile and much needed interaction, it is crucial to extend engagement to younger children, who are enthusiastic to learn about 'real' science and unlikely to have pre-formed opinions. This need is strengthened by reports that many primary school teachers, who teach across the curriculum, often feel less confident in delivering the science component of their teaching (Murphy *et al*., 2005; Royal Society, 2010; Ofsted, 2011) a problem that has the potential to turn children off science by the time they reach secondary school. Most primary school teachers are delighted to host scientists in schools either for one-off activities or longer term collaborations.

As people become more aware of synthetic biology it is imperative that the scientific community takes a proactive stance by introducing the possibilities that the technology presents to all ages while at the same time listening to the concerns of society, in order to shape an open environment from which to progress.

This article looks at one approach to achieve this.

A synthetic biology outreach project

The Science Art and Writing (SAW) Trust (registered charity no.1113386) was founded in 2006 and brings together scientists, artists and writers to collaborate with teachers on the design and delivery of science-themed projects in schools. SAW projects have proved to be particularly popular in primary schools, where children are extremely open to new ideas. Initially scientists worked with teachers to create SAW projects themed on areas of science covered by the national curriculum. The SAW Trust then began experimenting by introducing current scientific research into the classroom. This was received with great enthusiasm and interest by the children (Osbourn, 2009).

SAW projects offer a non-threatening way to engage children and adults in science, and the cross disciplinary approach means that projects are inclusive to people with different interests and learning styles.

A SAW project on the theme of synthetic biology took place in a Norfolk primary school with children aged 9 to 10 in September, 2011. Prior to the project, the scientist, artist and writer met with the teacher to discuss the theme and to map out what the children already knew. Many primary school children are familiar with the term DNA; some will relate it to crime investigations and others know that it is found in cells, but it is not part of the teaching requirement at primary school level. To run an activity on DNA with young children it is important that they understand the concept that DNA holds the instructions to how living organisms grow and survive in different environments and that this is passed on from parents to their offspring. This can be easily introduced to the class by looking at different animals or plants and asking the children to identify traits that make certain species suitable for any given habitat. Using the example of ingredients and recipes in a cook book has proved to be an easy way to get across the idea that to make something specific instructions must be followed. There is no need to go into any details related to the transcription and translation of DNA but it is beneficial to show the helical structure of DNA, which children are likely to have seen elsewhere. After a brief introduction to DNA, the children were introduced to the basic A,T,G,C code and then made DNA ladders out of plasticine, using different colour balls to pair bases on their ladders (Figure 1).

Figure 1. Children making DNA ladders out of plasticine as part of a Science, Art and Writing (SAW) project on the theme of synthetic biology.

Synthetic biology was then introduced as a strategy to solve a problem, in this case to enable plants to grow in severe drought conditions. Discussion and images were used to look at examples in nature that enable plants to survive in arid regions. Many children were familiar with the morphology of cacti but were interested to discover how the appearance of cacti was the consequence of evolution, carried on DNA. The children were encouraged to think of ways that plants could adapt to survive in the driest places on earth (no matter how unusual) and then wrote a short sequence of genetic code that would enable the change. They used the plasticine balls to assemble the new code on their ladders to represent how new ‘instructions’ can be introduced using synthetic biology, and then drew pictures of their modified plants to add to a desert scene (Figure 2).

Figure 2. A desert scene filled with children’s drawings of plants modified for drought tolerance. The children’s suggestions included protective chemicals, force field, suction cups for leaves, modified tap leaf, electric shield, super strong veins, modified water pipe root, spikes, legs to move, arms and shovel to dig for water, ability to create a storm, eats bumble bees, shooting vines, water tank in the plant, a wishing plant!

The modifications designed by the children demonstrate how limitless they perceive possibilities for science to answer the problems of the world, and this in many ways is the great motivator for all scientists. It is important to allow children to think outside the box and suggest wild modifications such as ‘a force field that protects plants from drought’ even if this is something that the adult brain finds hard to envisage. These are the seeds of ideas that create potential and that, no matter how sci-fi they sound, could be the innovations of the future just as the technologies pulled together for the first 'bionic man' in 2013 would have seemed to the surgeon who carried out the first metal hip replacement surgery in 1940!

As with all SAW projects, children then further explored the science theme through poetry and art (Figure 3).

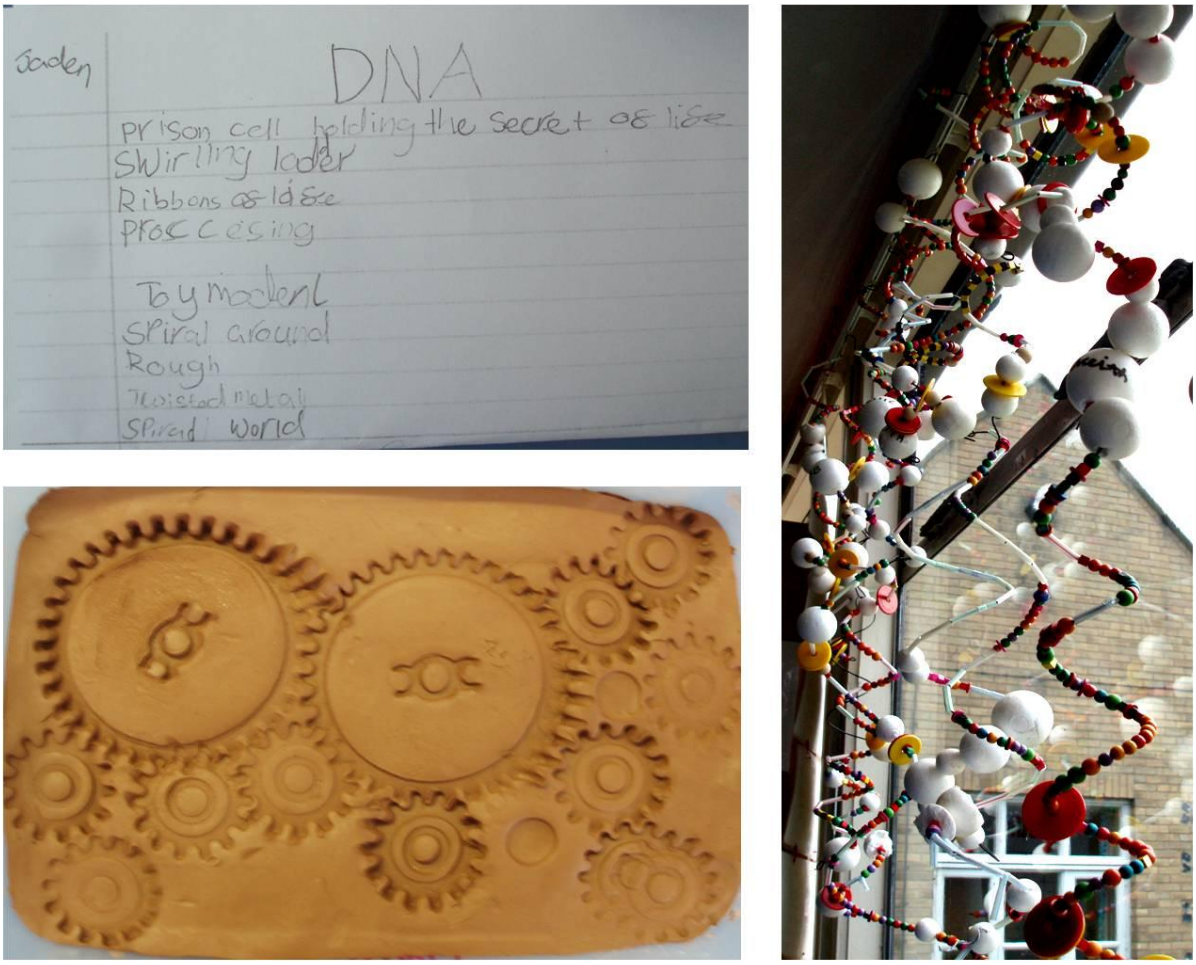

Figure 3. Examples of children's creative outputs in response to learning and DNA and synthetic biology.

This approach opens up science to children who are perhaps more confident in the creative arts, and also offers intriguing outputs that can be displayed and create the basis for discussions.

At a time when the views of society are so directly linked to policy it is crucial that scientists find creative ways to explore research topics with communities and enable everyone to participate in dialogue that spans research in laboratories and its relevance to everyday life.

The measure of quality of scientific engagement in schools should not focus solely on how many children go on to pick science for GCSE, A-Level,

degree or beyond. These activities create opportunities for important interactions that enable children to ask scientists questions in a non-threatening, informal setting.

Experiences at a young age can stay with us and it is hoped that investment in high quality science outreach activities will propagate a future society that is more interested in science and in which people feel more confident to formulate opinions on new technologies based on their own views.

Science, innovation and society – communication dilemmas

Synthetic biology has the potential to provide novel products and processes to support more sustainable lifestyles in developed and developing economies. Effective and balanced communication is key to enabling society to be more discriminating in judging the quality of evidence presented by advocates for or against particular scientific developments.

A continual provision of science engagement activities will enable future generations to better understand the costs and benefits that new research could bring to lifestyles and foster a culture where non-scientists feel confident in assessing evidence and forming their own opinions. Engaging with stakeholders that are interested in science can be a productive and pleasurable experience for researchers, even if there are concerns or controversy over the research theme.

The SAW Trust offers training and support to help researchers design and deliver bespoke outreach projects, often as a formal part of the pathways to impact delivery. For more information please contact info@sawtrust.org

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