



The Royal Academy
of Engineering

This response was submitted to the consultation held by the Nuffield Council on Bioethics on Emerging biotechnologies between April 2011 and June 2011. The views expressed are solely those of the respondent(s) and not those of the Council.

Emerging biotechnologies



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1. How would you define an ‘emerging technology’ and an ‘emerging biotechnology’? How have these terms been used by others? & 2. Do you think that there are features that are essential or common to emerging biotechnologies?

The Royal Academy of Engineering currently awards a research Chair in emerging technologies. According to the criteria for awarding this Chair, Academy understands an emerging technology to be, by definition: “immature and hence unlikely to be at stage where it can be further developed by industry”. The purpose of this definition is to highlight technologies that are not necessarily at a point where they might be supported by corporate investment, and would therefore benefit from sponsorship for further development. This definition, we believe, also alludes to the generally novel, provisional and potentially high-risk features of these technologies, where there is no assurance yet of efficacy or success in intended applications.

Such technologies, especially emerging biotechnologies, might also be perceived as potentially disruptive or potentially dangerous, because they hold great promise whilst been untested and unproven. However, there is no reason why the term ‘emerging technology’ or ‘emerging biotechnology’ should be loaded in a negative way, since their ‘emerging’ status surely relates only to their stage of development. Hence an emerging biotechnology is simply a biotechnology that is still in the research phase, but which is showing potential for further development and exploitation.

This is not to say that such technologies should not be considered in terms of their social value and impact, or the regulatory and ethical issues that they might give rise to if they were to be commercialised (or indeed used at all outside of the laboratory). Any technology has the capacity for both positive and negative uses. All technologies, whatever their stage of development, should continually be assessed for positive and negative impacts on society, or potential ethical issues surrounding their development and use.

3. What currently emerging biotechnologies do you consider have the most important implications socially, ethically and legally?

There are two relevant areas of technology that the Royal Academy of Engineering has investigated in recent years. The Academy carried out a study, published in 2009, into the state of the art in synthetic biology, a study that was accompanied by the UK’s first public dialogue to gather attitudes and views (both uninformed and informed) to synthetic biology and its potential applications and implications. The latter activity was followed by a much larger public attitudes research project carried out by EPSRC and BBSRC. The Academy has since been involved in an international collaboration on Synthetic biology, working with science and engineering academies from the UK, China and the US. This project is ongoing, with seminars to be held in China and the US, following on from an event hosted by The Royal Academy of Engineering and the Royal Society in April this year.

The Academy has also conducted two discussion meetings on autonomous systems. Though these do not fall exclusively within the realm of biotechnologies, autonomous systems have application in medicine (for example, telemedicine) and social care (for example, smart homes for the housebound and potentially artificial companions for children or isolated individuals) and might therefore fall within the remit of Nuffield Council’s studies. They also raise issues similar to those generated by other biotechnologies.

Both of these areas of technology are interesting in that they have applications that challenge the limits of our concepts of life and living systems. In synthetic biology we have the possibility of creating novel living systems or systems that are identical to 'naturally' occurring entities by 'artificial' means; and the possibility of artificially adapting naturally occurring systems. In autonomous systems we have non-human systems that are capable of observing, learning and decision making that may have control over people, or ultimately become companions to them. Both areas raise issues about the acceptability of introducing artificial entities or systems that are not straightforwardly living, or not human, within our lives and social structures. They challenge our concepts of life and personhood and therefore, raise issues for social norms and regulatory systems that are based on those concepts.

Synthetic biology and autonomous systems both hold great promise for improving health, independence and quality of life, and therefore these social, legal and ethical issues are worthy of discussion. This will allow these areas of technology to develop in a way that promotes their beneficial impacts whilst monitoring or controlling any potentially negative impacts.

5. Are there examples where social, cultural or geographical factors have influenced public acceptance or rejection of emerging biotechnologies?

The Academy commissioned a nationally representative omnibus survey in 2009 to complement the exploratory synthetic biology public dialogue activity that took place in the same year.¹ The results indicated that men were more likely to have positive attitudes towards either creating new life or adapting existing lifeforms than women. Similarly, younger people appeared less favourable towards modifying or creating micro-organisms. There were also some interesting regional differences. For example, a significantly greater majority of survey respondents in Scotland agreed with the statement 'Creating new man-made micro-organisms that will produce medicines or biofuels should be supported' compared with those in London and the south-east who were the least likely to agree.

8. Are there ethical or policy issues that are common to most or many emerging biotechnologies? Are there ethical or policy issues that are specific to emerging biotechnologies? Which of these, if any, are the most important?

A major common theme, as discussed above, is the issue of the idea of life and living things, and the possibility of creating or adapting life, and the idea of using non-living beings in social and health care. These complex ethical issues need to be addressed to develop appropriate policy and regulation for the area.

Another common issue is the idea of control, which was certainly common to both of the areas that the Academy has looked at. For example, participants in the synthetic biology public engagement activity tended to be concerned about the idea of releasing synthetically created or adapted organisms into the environment, because of the potential lack of control over them once released. Peoples' confidence in the safety of the technology related largely to the matter of the degree to which scientists were able to control the behaviour of organisms adapted or created.

In terms of autonomous systems, a major issue expected to be of concern in our debates was peoples' willingness to relinquish control to autonomous systems, such as autonomous vehicles. The idea of robots in all settings from the military to

¹ *Synthetic Biology: public dialogue*, The Royal Academy of Engineering 2009
http://www.raeng.org.uk/news/publications/list/reports/Syn_bio_dialogue_report.pdf

individuals' homes raises the issue of how the behaviour of autonomous systems can be controlled, if it is part of their very purpose that they can 'learn' from their environment and ostensibly make decisions beyond those enabled by their initial design – since their interaction with their environments can, potentially, lead to adaptations of the rules that determine their behaviour. Therefore, as with synthetic biology, there is a perceived risk that once deployed these technologies could escape our control, without a clear sense of who would be accountable and liable for their impacts.

These issues of control are however common to many technologies, including other emerging areas such as nanotechnology. Other 'generic' outcomes that have arisen from a variety of research projects on public attitudes, irrespective of the emerging technology under discussion include: safety considerations; motivations (for example is it for commercial gain or social benefit?); fairness (who will gain and who will lose out) and 'naturalness'/ tampering with nature. The issues relating to the concept of life and personhood might be specific to biotechnologies, and are relevant to areas such as stem cell research, but are perhaps not relevant to all areas of biotechnology.

9. Do you think that some social and ethical themes are commonly overlooked in discussions about emerging biotechnologies? If so, what are they?

The issues of ownership and allocation of benefits and profits from such technologies have always been a major issue, as demonstrated in public debates over GM technologies. In our study, biofuels were seen as the best area for focusing development, because of the potential for a greater number of people to benefit. However, these issues might be overlooked as some more 'intrinsic' features of the technologies and their applications get greater attention, such as, their safety, risk to health and so on.

10. What evidence is there that ethical, social and policy issues have affected decisions in (i) setting research priorities, (ii) setting priorities for technological development, and (iii) deploying emerging biotechnologies, in either the public or private sector?

Both the development and deployment of autonomous systems in particular are constrained by the lack of policy relating to them, which results in a lack of legislation and regulation. Regulation is needed at an early stage for the technologies to be developed, as industry will not invest in developing a technology that might in future be regulated against. Development of policy and regulation in turn depends on ethical debate concerning the use of autonomous systems. Technologies for autonomous robotic surgery are on the near horizon, but their deployment may be hampered by issues surrounding responsibility for error. Conversely, technologies for monitoring, which are an aspect of autonomous or smart homes, are in danger of being introduced without sufficient debate over their acceptability or regulation covering their use.

11. What ethical principles should be taken into account when considering emerging biotechnologies? Are any of these specific to emerging biotechnologies?

Since this area relates so closely to issues surrounding the concepts of life and personhood, then ethical principles which concern the need for respect for human and non-human life and respect for human personhood will be relevant. The ethical principles promoted by the Royal Academy of Engineering promote respect for life,

law and the public good, and these will be relevant.² However, this is an area where there is much conflict over the content of ethical 'principles', particularly as they might be influenced by religious views, so it will be difficult to identify universal ethical principles in this area.

12. Who should bear responsibility for decision making at each stage of the development of an emerging biotechnology? Is there a clear chain of accountability if a risk of adverse effects is realised?

One of the major issues in this area, as discussed above, is that of control. If synthetic organisms are ever to be released, then their behaviour and proliferation might go beyond technologists' control. Autonomous systems are by their nature beyond total human control. Therefore, the issue of accountability in this area is complex and critical. For autonomous systems in particular, the matters of accountability and responsibility need significant consideration and appropriate regulation needs to be developed for the area to move forward. Professional institutions can help to identify the issues at the early stages of technology development and regulators will take over in the later stages of technology development – although regulation should be developed before problems occur, not reactively.

14. To what extent is it possible or desirable to regulate emerging biotechnologies via a single framework as opposed to individually or in clusters?

It is likely that a mixture of general regulation concerning health and safety and specific caveats for individual technologies and groups of users will be needed. Although each technology and context of use must have specific consideration, many general issues concerning safety, contamination and control are likely to fall within existing legislation.

15. What role should public opinion play in the development of policy around emerging biotechnologies?

Where appropriate, policy should be developed with an understanding of public concerns, views and hopes regarding a particular emerging technology. Informed public attitudes, opinions and views should not *direct* policy and regulatory decisions but should be taken into account by policy makers alongside the views of other consultees and stakeholders, such as technical experts, economists and the business community.

Furthermore, by understanding the public's potential concerns and aspirations on new science and technologies, policy makers are then better prepared to discuss the implications with the media and the wider public.

16. What public engagement activities are, or are not, particularly valuable with respect to emerging biotechnologies? How should we evaluate public engagement activities?

Deliberative methods are very useful techniques in order to gather more in-depth thoughts and views of the public by enabling a dialogue to occur and time for the participants to become informed in the subject, meet technical experts, ask

²http://www.raeng.org.uk/societygov/engineeringethics/pdf/Statement_of_Ethical_Principles.pdf

questions, develop their opinions and enable the facilitators to 'unpack' those opinions to gain some understanding as to why they exist.

Public opinion surveys are also a useful way of capturing an overall picture of what the nation thinks and feels regarding a particular technology.

Utilising a mixed methods approach (for example; deliberative; qualitative and quantitative) is often a powerful way to capture a more realistic picture of public opinion in addition to more in-depth thoughts and considerations.

There are a number of ways that public engagement activities can be evaluated depending on what it is that one might want to explore. We would be happy to discuss this further if required, though it is too complex an area to cover briefly here.

17. Is there something unique about emerging biotechnologies, relative to other complex areas of government policy making, that requires special kinds of public engagement outside the normal democratic channels?

'Special kinds' of public engagement, such as dialogue and deliberative methods to gather informed and in-depth public views on a number of complex issues, all go beyond the usual democratic channels. There are many topics that could benefit from these activities, including climate change, sustainability, education, UK interactions with European government, the banking and financial sector. There does not seem to be anything unique to emerging biotechnologies that demands these public engagement activities, but rather many more areas of policy could benefit from this extra level of democratic participation.

Prepared by:

Dr Natasha McCarthy
Head of Policy
The Royal Academy of Engineering
3 Carlton House Terrace
London
SW1Y 5DG