The Academy of Medical Sciences

Response to the House of Commons Science and Technology Committee inquiry into genomics and genome-editing
January 2017

Summary

- Advances in genomics and genome-editing technologies hold great potential to improve human health, but also have ethical implications. We welcome the opportunity to contribute to ongoing discussions in these areas.
- However, while there may be instances where genomic understanding and genome-editing tools can be used together in basic or clinical research, these approaches are largely independent. Therefore their governing regulatory frameworks and ethical and safety considerations do not fully overlap. We urge caution that these topics are not routinely conflated and are each given due consideration in future discussions.
- Further, it is important that the use of genome-editing tools for basic research and their use in a clinical setting are considered separately; the safety, ethical, and regulatory considerations required for each application are distinct. Similarly, there are valid distinctions between the use of genome-editing tools in germline versus somatic cells which should be acknowledged.
- The Academy believes that the UK is particularly well placed to address the regulation of genome-editing due to its existing robust regulatory framework, in the form of the Human Fertilisation and Embryology Authority (HFEA) and the Human Tissue Authority. This regulation has been developed in consultation with experts and publics.
- We recognise that the decision to leave the EU may have important implications for the regulation of genomics and genome-editing technologies. The harmonisation of regulatory frameworks could promote ongoing European collaboration, but there is also opportunity to benefit from regulatory agility as these frameworks evolve.

Introduction

1. The Academy of Medical Sciences promotes advances in medical science, and supports efforts to see these advances translated into healthcare benefits for society. Our elected Fellowship includes some of the UK's foremost experts in medical science, drawn from a broad range of research areas.
2. We welcome this opportunity to respond to the House of Commons Science and Technology Committee inquiry into genomics and genome-editing. The Academy is monitoring the rapid developments and applications of genome-editing technologies, and is seeking opportunities to contribute to this debate.
3. In September 2015, together with other UK research organisations, we published an initial joint statement in support of the continued use of genome-editing techniques in basic and preclinical research.[1] In February 2016, we also responded to the Nuffield Council on Bioethics call for written evidence on genome-editing. Our submission drew on the expertise of our Fellowship, and focused on genome-editing in the context of biomedical research and clinical applications.[2] In April 2016, together with the Federation of European Academies of Medicine and the French National Academy of Medicine, we also jointly held a workshop titled *'The*

[1] Initial joint statement (2015). *Genome editing in human cells.* http://www.acmedsci.ac.uk/file-download/37773-55e6b4e90f49c.pdf
[2] The Academy of Medical Sciences (2016). *Response to the Nuffield Council on Bioethics Genome Editing Call for Evidence.* http://www.acmedsci.ac.uk/file-download/38579-56bc88dc0dea4.pdf

European landscape for human genome editing', providing an opportunity to facilitate international discussions and explore the scientific and regulatory landscape for human genome-editing across the EU.[3]

4. In addition, the Academy is engaged in work that explores the integral role of genomics in personalised healthcare, as well as the broader topics that form the basis of this consultation, including data governance and the support of the UK Life Sciences sector by the Industrial Strategy.[4,5,6,7]
5. The increasing generation and analysis of genomic data is greatly improving our understanding of human disease, and is providing new opportunities for patients to benefit from more targeted and effective treatments. This is supported by a growing infrastructure and national genomics data resources. Furthermore, the ability to exploit the emergence of efficient genome-editing tools - especially when coupled with this ever increasing genomic understanding - holds real potential to improve human health. However, there are important ethical considerations regarding the clinical use of these new technologies, and we welcome ongoing debate in this area.
6. However, it should be noted that, while there are instances where genomic understanding and genome-editing tools can be applied in a complementary fashion, in other instances the considerations raised by these two fields are wholly separate and independent; the clinical impact, regulatory frameworks, and ethical and safety concerns of these approaches do not fully overlap. We therefore urge caution that these topics are not routinely conflated and are each given due consideration in future discussions.
7. Our response to the six key areas outlined within the inquiry can be found below. They have been informed by several of our recent activities as noted above; we would be pleased to provide further evidence and copies of our relevant outputs as detailed in this response, if required.

Q1. The impact of genomics and genome-editing on:
a. wildlife and ecosystems, including potential uses in relation to infectious disease, re-introducing extinct species and controlling predator populations;
b. plants and animals, including in relation to food production; and;
c. human health, with regard to treating disease, avoiding genetic disease and human enhancement.

8. Our response to this question falls predominately within the scope of sub-question c: human health, with regard to treating disease, avoiding genetic disease and human enhancement.
9. Genomics and genome-editing techniques have the potential to have a profound impact on human health. This can be realised through their use in basic research to advance our understanding of basic biology and the genetic determinants of human diseases, and through their more direct clinical application for therapeutic or preventative treatment. The Academy believes that the merits and limitations are distinct for these different applications, especially

[3] The Academy of Medical Sciences (2016). *The European landscape for human genome editing.* http://www.acmedsci.ac.uk/file-download/41517-573f212e2b52a.pdf

[4] The Academy of Medical Sciences FORUM (2015). *Stratified, personalised or P4 medicine: a new direction for placing the patient at the centre of healthcare and health education.* http://www.acmedsci.ac.uk/file-download/38266-56e6d483e1d21.pdf

[5] The Academy of Medical Sciences FORUM (2016). *Exemplar clinical pathways for a stratified approach to cardiovascular disease.* http://www.acmedsci.ac.uk/about/objectives/linking-academia-industry-NHS/forum/forum-reports

[6] The Academy of Medical Sciences FORUM (2015). Exemplar clinical pathways for a stratified approach to diabetes. http://www.acmedsci.ac.uk/about/objectives/linking-academia-industry-NHS/forum/forum-reports

[7] Academy of Medical Sciences (2016). *Submission to the British Academy and Royal Society's call for evidence on data governance.* http://www.acmedsci.ac.uk/file-download/41614-583586af15320.pdf

in the case of genome-editing. Therefore, we have separated our response into sections focusing on each application.

Basic biomedical research

10. Genomics methods provide a powerful and unbiased approach that can be used to identify the molecular basis and biomarkers of specific diseases. In parallel, genome-editing technologies, and in particular the CRISPR-Cas9 system, have also widened the possibilities of basic and biomedical research. For example, genome-editing has enabled the rapid generation of new cellular and animal models of human disease. These include models incorporating genetic determinants of disease identified using genome-wide strategies - providing a complementary approach to genomics – and models that are closely genetically matched (isogenic) to a control, which help facilitate the precise determination of differences driven by the introduced disease mutations.
11. Genome-editing can, therefore, be used to rapidly investigate whether specific genomic changes cause disease, or to interrogate gene function. Thus, genomics and genome-editing are at the forefront of basic and pre-clinical research, which is fundamental to the development of new therapeutic and preventative strategies aiming to improve human health.
12. While raising more ethical concerns than basic research using somatic cells, the use of genome-editing in embryos for basic research - within the confines of regulation laid down by the Human Fertilisation and Embryology Authority (HFEA) - has the potential to improve our understanding of the role of gene products early in human development. This in time could be translated into clinical approaches to ameliorate or prevent disease. We are therefore supportive of such work, and welcome the HFEA's approval, in February 2016, of the research application submitted by Dr Kathy Niakan at the Crick Institute to use genome editing tools to investigate the genes required for the development of human embryos.[8]

Clinical applications for treating disease

13. Rapid technological advancements in the field of genome-editing now mean that the targeted and highly efficient editing of a genomic sequence in a clinical capacity has largely become a reality. For example, genome-editing techniques such as transcription-activator like effector nucleases (TALENs), zinc-finger nucleases (ZFNs), and more recently CRISPR/Cas9 can feasibly be used in the context of gene therapy. This provides a means to repair a disease-causing mutation, or to engineer beneficial changes to treat a disease.
14. Indeed, the use of genome-editing in gene therapy may have advantages over conventional methods. For example, the ability to edit a sequence in its normal genomic context may prove more precise than introducing a full gene by retroviral therapy, and also avoids the rare but realised risk of insertional mutagenesis.
15. Although the frequency of off-target events – changes that occur away from the intended genomic region - and other unintentional consequences of genome-editing should remain a focus of investigation, the Academy is encouraged that several clinical trials involving several genome-editing techniques are underway, including trials of specific T-cell modifications used to either treat cancer or manage HIV infection.[9,10] Such trials will provide important evidence of whether genome-editing methods, including CRISPR-Cas9, are safe for wider clinical use.
16. Genomics research is also beginning to have a clinical impact. Advances in this field, including through the 100,000 Genomes Project, will continue to help identify the genetic determinants of disease.[11] Such information can facilitate the development of improved diagnostics and

[8] https://www.crick.ac.uk/news/science-news/2016/02/01/hfea-decision/
[9] Tebas P, *et al* (2014). *Gene editing of CCR5 in autologous CD4 T cells of persons infected with HIV*. The New England Journal of Medicine **370**, 901–910.
[10] http://www.nature.com/news/first-crispr-clinical-trial-gets-green-light-from-us-panel-1.20137
[11] https://www.genomicsengland.co.uk/the-100000-genomes-project/

stratified therapeutic strategies, and many such advances are already being realised; some examples are included in our recent report on *'Stratified, personalised or P4 medicine: a new direction for placing the patient at the centre of healthcare and health education'.*[12] This report also notes, however, that for the potential of genomic medicine to be fully realised, there is a need for healthcare systems to evolve in order to keep pace with technological innovation and adapt to the new ways of delivering healthcare that this allows.

17. Researchers, clinicians, patients, and the wider public must have a robust understanding of genomics in order to better facilitate its adoption to improve healthcare. This is also critical in the context of genome-editing; a greater understanding of the possible merits (and limitations) of such tools is needed to ensure they are able to impact on human health in a beneficial - and trusted - manner. The importance of ongoing training and of dialogue between all stakeholders is explored in more detail in response to Questions 3-5.

Clinical applications for preventing disease

18. In addition to these applications to treat established diseases, genomics and genome-editing approaches could also be used to reduce the risk of diseases with known genetic factors, or even to prevent diseases altogether. In this regard, we recognise that there may, in the future, be increased emphasis on applying genome-editing to human germ cells or embryos with the aim of preventing the transmission of inherited diseases.
19. Although this is currently prohibited by law in the UK (and similarly not permissible in other European jurisdictions) such an application could offer an alternative to pre-implantation genetic diagnosis and pre-natal gene therapy, especially in cases where these already established options have limited utility. In some cases, the ability to edit the genome of a germ cell or embryo may be the only means by which parents are able to have a biologically related child unaffected by a hereditary disease - for example where both parents are homozygous for a recessive disease, or where one parent is homozygous for a dominant disease. While the number of such cases is likely to be limited, it is possible that more such cases will emerge as genomics research increases the number of known disease-predisposing gene variants or variant combinations.
20. It will be important to continue to assess the ethical considerations raised by the possibility of making heritable genome edits to the human germline. The UK has an extensive history of debating similar topics and engaging both experts and the public; this is explored further in our response to Question 3.

Human enhancement

21. The concept of human enhancement could be taken to encompass a wide range of approaches to improve human function, which might be restorative i.e. aiming to restore an impaired function to previous or average levels, or enhancing i.e. aiming to raise a function either beyond an individual's 'norm' or beyond current human limits. As noted above, the Academy is supportive of the potential to use genomic data and genome-editing technologies in a restorative capacity and to treat disease.
22. However, we are aware that there is public concern that any future therapeutic genome-editing of the human germline could set a precedent to permitting non-therapeutic human genetic enhancement. It might be technically possible to confer any phenotypic trait for which there is a well characterised genetic basis, although such examples are currently limited. Therefore, the potential restorative or enhancing effects of any proposed clinical genome-editing applications must be fully considered as part of a thorough safety and ethical review.

[12] The Academy of Medical Sciences FORUM (2015). *Stratified, personalised or P4 medicine: a new direction for placing the patient at the centre of healthcare and health education.* http://www.acmedsci.ac.uk/file-download/38266-56e6d483e1d21.pdf

23. It is not, however, possible to 'enhance' traits for which we do not fully understand the genetic contributions; these include many of the traits that are typically considered in discussions of 'designer babies', such as intelligence. We would raise caution that over-stating the capabilities of genome-editing, especially within the context of such ethically contentious applications, may adversely impact on the perception and ultimate success of novel developments which may be considered as beneficial, including advances made in non-heritable therapeutic approaches.
24. It may also be feasible to apply genomics methods alongside other approaches for human enhancement, such as the use of pharmacogenomics to determine which individuals might benefit from specific cognitive-enhancing drugs.[13] We must engage society in an open dialogue about the prospects of such enhancement technologies, allowing assessment of the acceptability of such applications.

Q2. Whether current regulations in particular areas of genomics and genome-editing are consistent, and whether they are adequate to meet the requirements of different 'product' and 'process' based approval processes.

25. Editing the genome of somatic cells in a research capacity is overseen by the Human Tissue Authority (HTA), created by the Human Tissue Act 2004. The clinical application of somatic cell therapies - including any that would be based on recently emerged genome-editing technologies - would similarly be regulated by the HTA and licensed by the Medicines and Healthcare products Regulatory Agency (MHRA). The Academy believes that these regulations are sufficient to manage the use of genome-editing technologies, including CRISPR, in both such scenarios.
26. We support the continued use of genome-editing in pre-clinical biomedical research, provided that the work is scientifically and ethically rigorous, and is in line with the relevant regulatory and legal frameworks. In the UK such pre-clinical research is permitted to involve germ cells and human embryos, up to 14 days old, provided it is within the confines of the Human Fertilisation and Embryology Act (HFEA), 2008. The Academy recognises that the HFEA provides a robust and sufficiently flexible architecture to govern the ethically sound use of embryos in such a way, and believes that these regulations are also adequate.

The European regulatory environment

27. It will be important to consider whether regulation of both basic research, and potential pre-clinical and clinical applications, of genomics and genome-editing should be harmonised with EU legislation post-Brexit. As European regulation evolves, regulatory harmonisation could facilitate our ongoing participation in European collaborations and initiatives, including multi-centre genomics programmes. If so, ensuring the UK is able to contribute to, and influence, the direction of such regulations will be important. Conversely, it may be of value to consider where Brexit may also present opportunities to benefit from regulatory agility, allowing the UK to drive research and innovation in this area.
28. The Academy's recent joint workshop on *'The European landscape for human genome editing'* considered the regulatory landscape for genome-editing across the EU. As noted in a background document developed to facilitate this workshop, there is a reasonable degree of harmonisation across Europe in the regulation of genome-editing of somatic cells for research, and an expectation that existing laws and guidelines relating to gene therapy will most likely

[13] Joint Academies workshop (2012). *Human enhancement and the future of work.* http://www.acmedsci.ac.uk/file-download/34506-12308aca.pdf

be adequate to regulate future clinical applications.[14] However, as the existing regulatory framework for its use in gene therapy (via the EMA's Advanced Therapy Medicinal Products assessment) is based on traditional gene therapy using viral vectors, there may be a need to reconsider some details of the regulatory oversight should different methods infer different safety related issues.

29. The regulatory context of genome-editing of the human germline is however highly varied across Europe, with respect to both research and clinical applications. While there is a general consensus that genome-editing of the human germline should not be permitted in a clinical setting, reflected by the ratification of the Oviedo Convention by most European countries, there is a lack of clarity on how this affects basic research, which is necessary to realise improvements in human health.[15]
30. In addition, there is a lack of clarity on the definition of the germline, as it is now possible to derive germ cells from iPS cells that originate from somatic cells. It may instead be useful to focus on the reproductive purpose of future applications. We believe that the UK is particularly well placed to address the complex regulatory issues surrounding genome-editing due to its extensive bioscience capacity and rigorous regulatory framework, in the form of the Human Fertilisation and Embryology Authority (HFEA). Existing regulations govern research and both somatic and germline therapies, and incorporate robust safety and efficacy safeguards. As such, they enable research that explores the possibilities of genome-editing, and its potential clinical applications, to continue without subjecting humans to undue risk.

Q3. The ethical, social and safety concerns from genomics/genome-editing in the treatment of disease and its impact on the environment.

31. There are important ethical, social, and safety considerations raised by the use of genome-wide and genome-editing technologies, especially when they are applied in a clinical setting. Patients and the public will play an important role in driving the adoption of new medical approaches, including those based on genomics and genome-editing methods. It is therefore vital that ongoing efforts are undertaken to explore the public views and concerns regarding such areas of innovation. Nonetheless, the Academy anticipates that many such concerns are neither novel, nor specific to these areas.
32. For example, some close parallels can be drawn between therapeutic applications of genome-editing in somatic cells and existing gene therapy approaches; both aim to modify a genetic determinant of disease for medical benefit, and importantly do not cause heritable changes. Therefore, the Academy believes any social or ethical considerations surrounding the use of these approaches are similar, providing a pre-existing regulatory framework. Indeed, genome-editing may be safer than conventional retroviral therapy, as discussed in paragraph 14. We support the development of new therapeutic approaches that use somatic cell genome-editing, provided there is sufficient evidence from research to justify their use.
33. Ethical and safety considerations are most pertinent to the potential use of genetic technologies to prevent diseases, rather than to treat pre-existing disease. The potential to generate heritable changes to the human germline is particularly contentious, and has important implications for broader societal values including disability. The clinical application of this approach is currently prohibited by law in the UK. Nevertheless, it is important to engage stakeholders in a broad reaching discussion of its ethical, social, and safety considerations. This will enable the evaluation of whether, in the future, these issues might be addressed

[14] The Academy of Medical Sciences (2016). *The European landscape for human genome editing.* http://www.acmedsci.ac.uk/file-download/41517-573f212e2b52a.pdf
[15] *Ibid.*

sufficiently to justify the legalisation of genome-editing of the human germline for specific clinical applications. The recent adoption of mitochondrial replacement therapies - following extensive public and stakeholder engagement – illustrates the type of inclusive dialogue that would be useful in this setting.

34. Recent studies that report a lower than anticipated frequency of off-target effects using the CRISPR-Cas9 technology have gone some way to allay safety concerns raised by the clinical application of genome-editing. However, although such work is reassuring - and has been achieved by allowing the use of such techniques in basic research - robust and extensive preclinical and clinical trials are clearly required before use of this approach is widespread.
35. However, such research must be integrated with discussions of the social and ethical implications of genome-editing, involving a wide range of international stakeholders. These include scientists, research funding bodies, ethicists, healthcare professionals, patients, and the general public. An open and inclusive dialogue will allow exploration of concerns for the safety and regulation of genetic technologies, alongside discussion of their potential benefits; this will be important to earn public support.
36. The protection and privacy of patient data is a key consideration raised by the clinical application of genomics. Active engagement with patients and the public to discuss data privacy and usage policies is required to build confidence and support this rapidly advancing field, and ensure that it is at the core of the UK's increasingly stratified approach to medicine. We explore this in more detail in our response to Question 4.

Q4. Genomics England's 100,000 sequenced genomes initiative, including its progress and safeguards (including data consent and security).

37. We welcome Genomics England's 100,000 Genomes Project, which is a major facilitator of the paradigm shift in the UK towards a personalised approach to medicine. The project is already facilitating a more detailed understanding of the molecular basis of disease, which will in turn enable the development of targeted therapies that tackle the root cause of a disease and can be administered as part of a stratified treatment approach. It is encouraging to see the progress being made as part of the initiative; more than 17,000 genomes have now been sequenced, and a recent statement reported the first children to receive genetic diagnoses for their rare, previously undiagnosed, genetic conditions as a direct result of the project.[16]
38. The 100,000 Genomes Project provides an important model for the collection, linking, and sharing of patient data. Access to high quality patient data is vital to the UK's outstanding medical research base, and also underpins improvements in clinical care. However, such data are understandably sensitive, and it is imperative that patients and the public understand the value of providing such data, how and why their data is used, and which measures are in place to protect their privacy. The Academy has been active in exploring data governance, particularly in relation to data access for research and clinical care, including through its response to the British Academy and Royal Society's recent call for evidence on data governance and its reports on '*Personal data for public good: using health information in medical research*', '*A new pathway for the regulation and governance of health research*' and '*Improving the health of the public by 2040*'.[17,18,19,20]

[16] https://www.genomicsengland.co.uk/first-children-recieve-diagnoses-through-100000-genomes-project/
[17] Academy of Medical Sciences (2016). *Submission to the British Academy and Royal Society's call for evidence on data governance.* http://www.acmedsci.ac.uk/file-download/41614-583586af15320.pdf
[18] Academy of Medical Sciences (2006). *Personal data for public good: using health information in medical research*. http://www.acmedsci.ac.uk/file-download/34792-Personal.pdf
[19] Academy of Medical Sciences (2011). *A new pathway for the regulation and governance of health research.* http://www.acmedsci.ac.uk/file-download/35208-newpathw.pdf

39. Active engagement with the public, clinicians and other stakeholders is needed to ensure transparency and trust around data collection and sharing. This is required to obtain high levels of patient consent, which is crucial for the collection of comprehensive and high-quality datasets. We will be supporting the independent patient data taskforce set up by the Wellcome Trust, which aims to encourage more effective dialogue on this subject.[21]
40. We believe that enabling access to such high-quality data, by allowing appropriate data sharing, provides the opportunity to improve patient care, enhance public health, and benefit scientific progress through research. Important data governance safeguards for the storage and access of patient data generated through the 100,000 Genomes Initiative are in place; data is stored in a safe haven at a central repository, and only amalgamated results with no patient-identifiable features are distributed for wider use. The safeguards set up through this project could leave a legacy of infrastructure and protocols to better facilitate global data sharing, more widely facilitating the adoption of stratified medicine.[22]

Q5. The adequacy of investment in infrastructure and skills/training in the NHS to take forward genome medicine.

41. The clinical adoption of innovative technologies, including those within the remit of genomic medicine, requires the adequate training of relevant healthcare professionals, both in the use of these specific technologies and in the broader skills of data collection, manipulation, and interpretation. Our recent joint meeting on stratified medicine explored the integration of genomic and other molecular 'omics technologies in NHS clinical care pathways and, through the identification of barriers to progress, made recommendations to improve infrastructure and training to better facilitate their adoption.[23]
42. It was proposed that the continued development of a nodular healthcare infrastructure that aggregates regional expertise and specialist services would facilitate the adoption of stratified medicine throughout the UK. The report details a variety of recent initiatives that have helped to develop infrastructure for the UK stratified medicine landscape, including the 100,000 Genomes Project's legacy of next generation sequencing centres, an established sample pipeline, bio-repository and large-scale data store. However, we noted a number of outstanding barriers to the use of 'big data' in clinical practise, including technical challenges for the management of extremely large datasets, and challenges of scale involved in extending pilot studies to the whole UK population and beyond.[24]
43. There is a need to promote the development of expertise in stratified medicine within both the current and future NHS workforce. This will require both capacity building within the existing biomedical workforce and a new approach to the education of future generations.[25]
44. Our '*Health of the Public in 2040'* report recommends that training in quantitative skills is incorporated at an early stage for current and future researchers and health and social care practitioners. The report also recommends that higher education institutions and key research

[20] Academy of Medical Sciences (2016). *Improving the health of the public by 2040*. http://www.acmedsci.ac.uk/file-download/41399-5807581429f81.pdf
[21] https://wellcome.ac.uk/news/independent-patient-data-taskforce-announced
[22] The Academy of Medical Sciences FORUM (2015). *Stratified, personalised or P4 medicine: a new direction for placing the patient at the centre of healthcare and health education.* http://www.acmedsci.ac.uk/file-download/38266-56e6d483e1d21.pdf
[23] *Ibid.*
[24] *Ibid.*
[25] The Academy of Medical Sciences response to the House of Commons Science and Technology Committee 'Closing the STEM skills gap' inquiry (2017).

funders further enhance training pathways in informatics for health, in order to build a critical mass of expertise that can take full advantage of the genomics revolution.[26]

45. There is also a need for increased collaboration between medical research scientists, mathematicians and computer scientists.

Q6. The extent to which genomics should be part of the Industrial Strategy initiative.

46. The UK Life Sciences sector has clear opportunities for future economic growth. It is important to ensure that the UK capitalises on its biomedical research excellence by supporting its translation into the development of new clinical products and therapeutic opportunities that will benefit the economy.
47. In order to support the growth of UK based companies and promote international investment, the UK must develop an attractive environment for basic research and healthcare product development and manufacture. This would be supported by promoting the rapid adoption of new healthcare products within the NHS.
48. One area likely to see significant growth in the near-term future is the application of genomics and related technologies; new healthcare products and therapeutic strategies can be predicted to build on these approaches that underlie the increasing focus on personalised medicine. The NHS could play a key role in the development of gene therapy as an important therapeutic strategy.
49. In addition, the UK's unique strengths in health data and data sharing and the emergence of national genomics data resources create a unique opportunity for economic growth in data analytics. We welcome investment in genomic healthcare initiatives and their infrastructure. A boost to investment and innovation in these areas, as part of the Industrial Strategy, would ensure that the UK becomes a global leader in the development, manufacture, and commercialisation of emerging products and services.

This response was prepared by Anne Turberfield (Policy Intern) and was informed through the Academy's previous activities. For further information, please contact Dr Rachel Brown, Policy Officer (rachel.brown@acmedsci.ac.uk; +44(0)20 3141 3223).

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[26] Academy of Medical Sciences (2016). Improving the health of the public by 2040. http://www.acmedsci.ac.uk/file-download/41399-5807581429f81.pdf