

# NUFFIELD COUNCIL ON BIOETHICS

## Long list of topics for 2022 ‘What’s on the horizon?’ infographic

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## Beginning of life

### **Preconception screening**

Couples with a family history of inherited medical conditions such as cystic fibrosis can have genetic testing before they conceive to find out if they are carriers. Testing is likely to become cheaper and more accessible, allowing any couple to test for a wide range of genetic conditions and features relatively cheaply. In the future, extended genetic screening could become a requirement for gamete donors. This and other options are currently being considered as part of the revision of the EU Tissue and Cell Directive. Should there be limits on what people can test for?

### **Egg, sperm and embryo freezing**

As freezing techniques improve, gamete, and embryo freezing is emerging as a viable way of extending and preserving fertility. The number of people choosing to freeze their eggs is growing, and some companies offer egg freezing as an employee benefit. The storage time limit for electively frozen gametes and embryos will soon be increased from 10 years to 55 years. Should we be worried about people feeling coerced to freeze their eggs, and what could be the knock-on social effects of this trend? Is this another example of a technological solution to a social problem? [Read our briefing note on egg freezing.](#)

### ***In vitro* derived gametes**

Mouse sperm and eggs cells have been created in the lab from other cells in the mouse's body, resulting in fertile offspring. If this became possible for humans in future, it could offer a new kind of fertility treatment for people who cannot conceive, and overcome the shortage of eggs for research. Questions are raised about whether people should be allowed to conceive using 'artificial' gametes at all. This could increase the risk of children being produced without one parent's consent or knowledge, and raises questions about what ethical significance ought to be placed on genetic parenthood.

### **Genome editing in human reproduction**

It could become possible to use genome editing to alter the DNA of embryos, sperm or eggs to help a couple have a child without a particular heritable disorder. This is currently illegal in the UK. Before it can be permitted, it is widely agreed that consideration is needed of the clinical safety of the techniques, and their potential to impact on the welfare of the future person, and on discrimination and division in society. The announcement by a Chinese researcher that gene-edited twin girls have already been born has been condemned by scientists and ethicists around the world. [Read our report on genome editing in human reproduction.](#)

### **Whole genome sequencing of embryos and fetuses**

Couples and individuals can choose to have prenatal screening of fetuses for some genetic conditions in the first trimester of pregnancy. Embryos can undergo pre-implantation genetic screening during IVF. The number and type of conditions that embryos and fetuses can be screened for is likely to increase, with whole genome sequencing a possibility in future. This could provide important information to parents and promote reproductive choice, but there are concerns about the impact of

expanded prenatal testing on termination rates, and on the lives of people with disabilities. [Read our report on non-invasive prenatal testing.](#)

### **Womb replacements**

Researchers have been able to keep premature lambs alive in artificial wombs for several weeks. This technology might help improve outcomes for premature human babies in future. Looking further ahead, if more or all of pregnancy might one day take place outside the human body, would the use of artificial wombs lead to social changes relating to the nature of motherhood and parenthood?

### **Surrogacy**

Surrogacy, where a woman bears a child on behalf of someone else or a couple, is becoming more common. Currently, the intended parents have to wait until the child has been born and then apply to court to become the child's parents. There is also a lack of clarity around payment. In 2019, the Law Commission ran a consultation on UK surrogacy law, with many respondents declaring the law as not fit for purpose. The Law Commission will produce a report with recommendations for reform of the law and a draft Bill in autumn 2022.

### **Abortion**

Debate about UK abortion law is likely to continue well into the future. This is a polarised issue that has implications for areas of medicine such as prenatal screening. Some are campaigning to decriminalise abortion across the UK, but others are seeking to reduce the upper time limit for abortions in response to changes in the thresholds of fetal viability.

### **Fetal intervention**

Surgical interventions can be performed on fetuses *in utero* to manage life-threatening conditions and prevent disability, for example to repair heart valves, drain blocked bladders, and correct diaphragmatic hernia. These interventions expose both fetuses and pregnant patients to a number of long- and short-term risks and involve complex trade-offs between fetal and maternal benefits and risks. Researchers are exploring prenatal treatments for Down's syndrome, potentially offering parents additional options following a prenatal diagnosis. In what cases should fetal interventions be offered, and what are the implications for prenatal screening?

### **Whole genome sequencing of newborn babies**

The UK Government has announced an ambition to offer whole genome sequencing to parents of all newborn babies to identify babies' risks of developing disease and to create a genetic data resource for research and future healthcare purposes. This is likely to be available in the near future to parents through commercial genetic testing companies. Will this have real benefits for the health of children, or simply create confusion and worry for parents, and is it ethical to obtain and store this information without the child's consent? [Read our briefing note on whole genome sequencing of babies.](#)

## **Surgery in intersex infants**

People born with variations in sex characteristics may undergo surgery during infancy, before being able to consent to medical treatment. While, on some occasions, surgical procedures are necessary to avoid long-term risks to an individual's health, a significant number of interventions are performed primarily for cosmetic reasons, for example to normalise the appearance of genitals. Should cosmetic surgery for intersex infants be delayed until they are able to decide for themselves, and what would be the implications of that for the child?

## **Health and society**

### **Public health emergencies**

The COVID-19 pandemic has highlighted the ethical challenges which can arise during public health emergencies at both the individual patient level and the population level. National responses have involved significant interferences with individual liberty and required governments make trade-offs between competing values and interests. Matters of equity and fairness have arisen in relation to decisions about allocation of scarce resources and the development and distribution of treatments and vaccines. There has been debate around whether there is an 'acceptable level of deaths' in a public health emergency. Planning is needed to ensure societies are practically and ethically prepared for the next public health emergency and that they are able to rebuild afterwards. [Read more about our work on COVID-19.](#)

### **Vaccinations**

In 2019, the World Health Organization declared that vaccine hesitancy is one of the world's top ten global health threats. The reasons for vaccine hesitancy involve the interplay of social, cultural and personal factors. Decisions about how to respond to it require consideration of how much weight should be given to individual rights versus the collective interest - can mandatory vaccine programmes be justified? Wider ethical questions around vaccination relate to research and development; equity of access (nationally and globally); and, where vaccines are in short supply, how access should be prioritised. [Read more about our work on vaccination.](#)

### **Health screening**

Whole populations are offered health screening at various life stages to identify those at risk of developing diseases such as cystic fibrosis and cancer. Early diagnosis can enable earlier intervention, and reduce morbidity and mortality. At an individual level, ethical issues centre around questions of informed consent and choice, and the potential for harm through over-diagnosis, over-treatment, anxiety, stigma, and false negatives. On a population level, the focus is on issues of resource allocation, fairness and equity of access. The potential for genomic sequencing to be utilised in more screening programmes in future raises particular questions about what results and information should be returned or withheld, how much uncertainty people are willing to accept, and whether the purpose of screening should expand

beyond improving the health of the screened individual to benefiting the person's family, the NHS and wider society. [Read more about our work on screening.](#)

### **Non-communicable diseases**

Non-communicable diseases (NCDs) kill 41 million people each year, equivalent to 71% of all deaths globally. Cardiovascular diseases account for most NCD deaths, followed by cancers, respiratory diseases, diabetes, and mental health conditions. Tobacco use, physical inactivity, air pollution, the harmful use of alcohol and unhealthy diets all increase the risk of dying from an NCD. In 2015, NCDs were adopted by the United Nations General Assembly as a sustainable development priority for all countries. Public health measures to tackle the causes of NCDs raise complex questions about the relationship between the state and its citizens, the responsibilities of individuals towards each other, and public attitudes towards diseases that might appear to be self-inflicted, for example due to obesity. There can be tensions between emphasising individual-level action and a systems approach that pays attention to broader structural factors, global and national inequalities, health system drivers, and social determinants of NCDs. [Read our work on public health ethics.](#)

### **Antimicrobial resistance**

The emergence and spread of drug-resistant pathogens (bacteria, viruses, fungi, and parasites) threatens our ability to treat common infections. The drivers of antimicrobial resistance (AMR) cited by the World Health Organization include the misuse and overuse of antimicrobials, poor infection and disease prevention and control in health-care facilities and farms, lack of awareness and knowledge, and lack of enforcement of legislation. AMR raises ethical questions such as who should have access to antibiotics, whether the physician's moral duty is towards the patient's current need or toward potential future patients, and whether our current use of antibiotics should be restricted out of consideration of future generations.

### **Mental health and wellbeing**

There is increasing attention on the need to promote wellbeing, build resilience and prevent mental health problems. A person's mental health can change over time, with periods where they may struggle and other times when they feel well. Environmental factors such as trauma, isolation, poverty and discrimination are risk factors for poor mental health. Public mental health interventions that seek to mitigate these factors can play a role in improving mental health. In addition, researchers are working on ways to prevent and treat mental illness. Areas of exploration include identifying genetic risk factors for mental illness; machine learning algorithms to analyse brain scans and identify abnormalities; digital technologies to deliver psychological therapy; and psilocybin therapy to treat depression, anxiety and a range of other mental illnesses. There are questions around the effectiveness and accuracy of these approaches, challenges in ensuring privacy and security of large amounts of sensitive data, the potential implications of increasing individual responsibility for one's own health and the extent to which we are taking an overly medicalised approach to mental health. [Read more about our work on mental health.](#)

## **Behavioural sciences and policymaking**

Behavioural sciences are gaining influence in policymaking. Governments and non-governmental organisations around the world have established behavioural science units to inform innovations in a variety of policy fields, including health and the environment. However, concerns have been raised about the way in which behavioural research is conducted, relating to the use of small sample sizes, non-diverse datasets, and unvalidated measures. This raises questions as to the suitability of using behavioural sciences to inform solutions for pressing social issues.

## **Prioritisation in the NHS**

COVID-19 has led to an increase in the number of people waiting for planned treatments and diagnostic interventions. While countries continue to grapple with fluctuating infection rates and high demand on health services, managing and prioritising elective care for different groups of people will involve difficult decisions and trade-offs. A key challenge for policy-makers will be ensuring that fairness and equity are at the heart of decision-making. [Read our background paper on funding pressures in the NHS.](#)

## **Racial inequalities in health**

Existing racial and ethnic inequalities and the policy response to the pandemic have led to COVID-19 having a disproportionate impact on people from ethnic minority backgrounds. Socioeconomic factors cannot always explain this disproportionate impact and structural racism can lead to people from ethnic minority backgrounds having poorer health outcomes. This raises questions about how health policy is formed, who is involved in policy making processes, and whether the perspectives of affected groups are represented. There are calls for health policy to focus on equity and the circumstances of groups at greatest risk.

## **Medical tourism**

Medical tourism is the practice of people travelling across international boundaries to access medical care and treatment, including dental care, cosmetic surgery, fertility treatment, and cancer treatment. Medical tourism can enable people to access treatments that are unavailable or prohibitively expensive in their home country, but raises issues of safety, continuity of care and fair distribution of medical resources. Illegal organ trafficking, where people travel to purchase organs from people living in poverty, has reportedly increased since COVID-19 due to the pandemic's effect on poverty levels and the global demand for organs.

## **Gender identity**

Increasing recognition of people with a range of gender identities has spurred significant public debate about gender and biology, appropriate medical intervention, and social acceptance. What does this mean for gender restricted roles and activities, such as sporting competitions, and how should interventions that pause puberty or alter sexual characteristics be made available to children and adolescents? [Read our work on the care and treatment of children and adolescents in relation to their gender identity.](#)



## **Disagreements in patient care**

Disagreements about the best course of action and appropriate treatment for a patient can arise within healthcare teams, between doctors and patients, and within families. Disagreements are complicated when the patient cannot make the decision for themselves, for example if they are unconscious or lack capacity. There have been several recent high-profile court cases where healthcare teams and parents disagreed about the care of a critically ill child. Wider changes in society, such as increases in social media use and medical tourism, and advances in medicine, might be contributing to the way in which disagreements develop. [Read our briefing note on disagreements in the care of critically ill children.](#)

## **Experimental medical treatments**

Patients, or parents and carers of patients, with limited options might wish to try experimental treatments despite uncertainties about safety and efficacy. Now that patients can easily find out about experimental treatments online, and crowdfund to pay for them if necessary, a key challenge is respecting the interests and autonomy of patients while ensuring they are protected from harm. The professional and ethical responsibilities of those developing, promoting and prescribing experimental treatments are also important. For example, many fertility treatment 'add-ons' have little or no evidence to show they are safe and effective. There can be blurred lines between treatments that are considered to be experimental and those that are used 'off-label' or through exemption schemes, raising questions about what kind of evidence is enough evidence in good clinical practice and how treatment decisions should be made in the face of imperfect evidence. [Read our briefing note on experimental treatments.](#)

## **Assisted dying**

In the UK, assisting or encouraging another person to commit suicide is a criminal offence. There have been several attempts to liberalise the law to align with some European countries and states in the USA, but this has been met with resistance, notably from the medical profession. However, in the UK, the Royal College of Physicians and the British Medical Association have adopted a neutral stance on assisted dying, having previously opposed it. MPs rejected an Assisted Dying Bill in 2015. An Assisted Dying Bill was put forward and debated in the House of Lords in 2021.

## **Treatments for biological ageing**

Much effort is going into finding treatments that could delay biological ageing, thereby reducing the risk of age-related diseases and conditions. This area of research is called geroscience or biogerontology. Clinical trials of drugs that target ageing are already underway. If effective interventions became available, these could have implications for health and lifespan, the economy, models of care, personal identity, and how people work and live later in life. [Read about our current inquiry on the future of ageing and our briefing note on the search for a treatment for ageing.](#)

### **Microbiome research**

Research is exploring how the human microbiome – i.e. the microorganisms living in the body – can be manipulated for therapeutic benefit. Treatments already in use include faecal transplants and dietary supplements. Microbiome analysis can reveal information about a person's behaviour, and microbiome composition has been known to affect behaviour. Microbiome research and intervention raises questions common to other areas of medicine about privacy and the nature of individual responsibility for health.

### **Epigenetics**

Researchers are understanding more and more about epigenetics – changes in gene expression caused by environmental effects, such as diet, stress, smoking, and childhood trauma. These effects might begin in the womb. Epigenetics research could have applications in many areas of policy, such as public health, healthcare and early years intervention. As the science develops, ethical issues relating to intergenerational equity, medicalisation of social problems, and privacy will need attention. [Read about a workshop we held to the explore the issues raised by epigenetics.](#)

### **Polygenic risk scores**

Polygenic risk scores are an assessment of a person's heritable risk of developing diseases that are influenced by multiple genes, such as coronary artery disease, type 2 diabetes and common cancers. Research on polygenic risk scores has accelerated thanks to the availability of large datasets and new statistical methods, and advances in genome sequencing technology. As well as health, polygenic risk scores may have applications in sectors such as education and crime prevention. As the science advances, there are questions around the applicability and utility of polygenic risk scores across groups with different genetic ancestries and environmental exposures.

### **The science of learning**

There are a range of scientific disciplines and perspectives addressing questions of how children, young people and adults learn and develop, particularly in the fields of cognitive and developmental psychology, neuroscience, and behavioural genetics. There is also growing interest in the relationship between the brain, genes and environmental factors. There are questions about the ethical application of this area of research in educational practice and policy.

### **Cognitive enhancement**

Techniques to stimulate brain function have been used for many years. New drugs, technologies, gene editing and stem cell techniques have the potential to enhance cognitive function such as concentration, impulse-control, memory, motivation and problem solving. They have applications in a range of contexts, including health, business, education, military and sport. Ethical questions are raised around authenticity vs naturalness, consent particularly in the context of minors, fairness, identity and equality of access. Cognitive enhancement devices, such as brain-computer interfaces and transcranial direct current stimulation, are increasingly

available direct to consumers, raising questions about the safety and regulation of such technologies. [Read our work on novel neurotechnologies.](#)

### **Moral enhancement**

Some philosophers suggest that moral enhancement is necessary for tackling the major challenges facing society such as climate change and racial discrimination. Traditional means of moral enhancement include explicit instruction and consciousness-raising, but could and should we intervene in the biological bases of human morality, using drugs, genetic selection or neurotechnologies, to influence a person's sense of morality and fairness? Critics argue that this would undermine people's autonomy and freedom to do wrong.

### **Sports enhancement**

Sporting performance can be improved through biomechanics, genetics, materials science, nutrition, pharmaceuticals, physiology, psychology, and surgery. Technology is advancing all the time. Where should the lines be drawn and where do responsibilities lie for the potential harmful effects and other consequences? [Read our background paper on sports science and medicine.](#)

### **Xenotransplantation**

Tools such as genome editing could, in future, lead to the production of organs that are safe for transplantation from animals to humans. This could help address shortages in organs for transplant and reduce or eliminate the need for human organ donation. However, using animals to create organs might not be acceptable to people for animal rights or 'yuk factor' reasons. Greater availability of organs might lower the threshold for transplantation, affecting incentives to live healthily. [Read our report on xenotransplantation.](#)

### **Cryonic freezing after death**

Cryogenic freezing of humans in an attempt to avoid permanent death is commercially available, but the likelihood of ever being revived is vanishingly low. Cryonic freezing services are not regulated in the UK, and there are concerns about companies making misleading claims and false promises. However, some people are opting to pay large sums of money to be cryogenically preserved after death. This can create intense challenges for families who disagree with their relative's wishes and raises questions about the morality of attempting to avoid death.

## **Data and technology**

### **Artificial intelligence in healthcare**

A wide range of applications of artificial intelligence (AI) are being explored in the healthcare sector, with considerable public and private investment and interest. AI is being used or trialled for detection and diagnosis of disease, management of chronic conditions, delivery of health services, and drug discovery. Ethical issues to consider include difficulties in validating the outputs of AI systems, and the inherent biases in

the data used to train AI systems. [Read our briefing note on AI in healthcare and research.](#)

### **Virtual and augmented reality in healthcare**

Virtual reality (VR) and augmented reality (AR) that emulate or modify perceptions of reality have a number of potential applications in healthcare, e.g. surgery assistance, pain management, psychotherapy, rehabilitation, and training of healthcare professionals. These technologies raise questions of effectiveness, particularly with regard to clinical mental health and mental wellbeing. Such technologies could result in personal data capture and use that would require protection from unintended uses, and there are risks that virtual environments could be too realistic, causing confusion between real and virtual worlds.

### **Health data and research**

The volume of health data that is collected and shared has grown exponentially in recent years. This includes genomic data and data generated by smartphones and wearables. There is a high economic and political interest in the potential of health data to advance scientific research and bring benefits to patients. Those governing and designing data initiatives find themselves in a situation where they are obliged to generate, use and extend access to data, while at the same time protecting individual private interests. The UK Government is currently exploring reforms to data protection legislation, which could include extending data access in 'the public interest' and a new, separate lawful ground for research. What are the implications of such reforms for the relationship between private and public interests, and public trust in data governance processes? [Read our report on biological and health data.](#)

### **Secondary uses of genetic information**

Healthcare institutions and companies that provide genetic testing services are collecting large amounts of personal genetic information that could be used for secondary purposes. Genetic databases are commonly accessed by researchers, both in the public and private sectors, and genealogy databases have been accessed by the police in the US. Individuals themselves can upload their genetic data to find out about genetic predisposition to disease or parentage. Future uses of genetic data are difficult to predict. There are questions about what kind of consent is required in these situations, how data should be controlled and used, and whether individuals should have a share in any profits made from its use. Find out more about our work on genetics and genomics.

### **Digital twins**

A digital twin has been described as a virtual representation of a living person or organ that spans its lifecycle, is updated from real-time data, and uses simulation, machine learning and reasoning to help decision-making. A digital twin combines various emerging technologies such as AI, Internet of Things, big data, genetics and robotics. Digital twins have the potential to improve health and enhance patient autonomy and freedom. However, there are questions of how far a digital twin can represent a person and what the consequences of this may be. Areas of risk include privacy and ownership of data, disruption of existing societal structures, inequality and injustice.

## **Robotics in healthcare**

Robotic technologies have the potential to carry out administrative, caring, diagnostic, mobility, and surgical tasks within the healthcare setting. Robotic-assisted surgical systems have been approved by the FDA in the US, and the Japanese government is hoping robots will help meet the care needs of its ageing population. [Read about our current inquiry on the future of ageing.](#)

## **Wearable technology**

Wearable devices are starting to be used for monitoring and managing health conditions, with the aim of improving health and patient engagement. The use of these technologies in people with impaired capacity and where power relationships between doctors and patients are imbalanced require particularly careful consideration. Wearables manufacturers are collecting large amounts of data which could provide useful information about population health. However, this data is of a sensitive nature, and devices can be vulnerable to hacking. Read about our work on the role of technology in the future of mental healthcare.

## **Biohacking**

Biohackers apply the hacker mentality to change or enhance the human body using, for example, devices and implants, gene editing, drugs and pathogens. The emphasis is on self-experimentation, creation, and modification of existing technology. Should biohackers be prevented from making choices that could be categorised as harming themselves, and do they pose a threat to national security?

## **Medical implants**

Medical implants are used to replace body parts such as hips or knees, deliver medication such as pain relief, and monitor and regulate body functions such as heart rate. There have been calls for regulatory reform to enhance the safety of implantable devices such as pelvic mesh and metal-on-metal hip implants. There are also concerns about transparency of the approval process and conflicts of interest in the system. Challenges for policy makers include ensuring effective post-market surveillance of implants, promoting innovation that addresses patient need, and preparing for data and cybersecurity risks associated with connected implants. In 2021, the Medicines and Healthcare products Regulatory Agency began the process of reviewing the regulation of medical devices in the UK. [Read our briefing note on medical implants.](#)

## **Technology in mental healthcare**

Technologies such as virtual reality and computer games are being developed as potential treatments for people with psychosis and anxiety. Apps and other technologies could lend themselves well to supporting people with mental health issues. They can offer immediate help, and some patients may feel more comfortable in disclosing symptoms to chatbots and virtual agents. Trust in the confidentiality of these conversations will be vital. A controversial area of research is using data collected through social media, smartphones, and other personal devices to monitor individuals' mental health and predict the risk of relapses, suicide and self-harm. There are concerns about stealth monitoring, lack of evidence for the effectiveness of many digital interventions, and the implications of the lack of human

support. [Read about our work on the role of technology in the future of mental healthcare.](#)

### **Technology in social care**

A wide range of technologies could play a role in social care contexts. Internet of things systems, assistive technologies, wearables and robotics could provide practical, social and emotional support to people at home, as well as monitoring and responding to user needs remotely. Alternatively, they could be used in ways that disempower and control older and disabled people, rather than supporting them to live in the way they wish. Automation and increasing reliance on technologies also give rise to questions about the reliability and safety of these technologies, and about transparency and accountability if something were to go wrong. Concerns have been raised about the potential for a loss of human contact and whether technologies would help to address or exacerbate loneliness and social isolation.

[Read about our current inquiry on the future of ageing.](#)

### **Novel neurotechnologies**

Technologies that intervene in the brain, such as brain-computer interfaces, offer the potential to help many neurological conditions, like Parkinson's, stroke, and chronic pain. Although there are many possible benefits, the potential unintended consequences require careful consideration. The unique status of the brain as the organ of the mind raises ethical and social concerns around personal identity and autonomy, moral responsibility, and free will, which are not seen in the context of other biomedical technologies. The potential for non-therapeutic applications give rise to further questions about the ethics of cognitive enhancement and dual use, while the emergence of the field of 'neurorights' calls for greater consideration of rights to cognitive liberty and mental privacy and integrity. [Read our report on novel neurotechnologies.](#)

### **Bioengineering**

Bioengineering refers to the application of engineering principles and techniques to biological processes and systems, including medicine, agriculture, and food. The concept is not new, but many potential future applications present new ethical challenges: for example, 'bioelectronic medicine' (the use of implanted devices to read and modulate electrical activity in the body, for the purposes of diagnosis or treatment - or possibly regeneration and enhancement); the use of 3D printing to create complete replicas of organs and cells; and the use of nano-materials for diagnostic or therapeutic purposes. Questions around human enhancement, identity, regulation and access, and the potential for dual use should be considered alongside research and development in this area.

### **Nanotechnology**

In the future, advancements in nanotechnology could have applications in different fields of medicine and biology. For example, nanomaterials could help fight antibiotic resistance, improve treatment and detection of cancers, and change the way in which drugs are delivered to make them more effective. However, the interactions of nanomaterials with cells, animals, humans and the environment are still poorly

understood. This raises questions about the potential impacts of nanotechnology on the health and safety of humans, animals and ecosystems.

### **Identification biometrics**

Future identification biometrics might include gait, voice, breath and heart rate recognition, with possible applications in criminal justice, security, healthcare, and commercial fields. Mirroring questions raised by the use of DNA, fingerprints and facial images, will these new biometrics be reliable, and how can they be used in a way that's proportionate to the aim of solving crime, for example?

### **Forensic DNA phenotyping**

Predicting what someone will look like – their phenotype – from a sample of their DNA is still a fairly inaccurate science, limiting its use in criminal investigations. It is starting to be used in Europe to estimate biogeographical ancestry, eye colour and age. DNA photofitting is a more speculative area. As our understanding of genomics advances, DNA phenotyping is likely to become more precise, but its use is likely to raise concerns about racial bias and discrimination, data storage and appropriate use of private information, and the potential for misuse.

### **Neuroscience and crime**

Brain scans and the resulting neuroscientific data have a range of potential uses in the criminal justice system, for example assessing competency to stand trial, criminal culpability, witness credibility, the risk someone will commit a crime or reoffend, and for lie detection purposes. Even if the technology was proven to be reliable, it would raise a host of ethical issues relating to coercion to undergo scanning, the framing of criminal responsibility, and the possibility of new interventions for criminals being developed.

### **Dual use technologies**

Many technologies can be used for both peaceful and hostile ends. This has always been part of violence between individuals and groups, especially in the context of civil unrest, disagreement and warfare. Do some new technologies, such as synthetic biology and neurobiology, prompt particular concerns about dual use? [Read our background paper on dual use in biology and medicine.](#)

## **Animals, food and environment**

### **Environment and health**

Human health is closely connected to the health of other animals and the environment. Environmental hazards such as food contaminants and air pollution have been linked to serious illnesses, including cancer, depression and heart disease. Climate change affects the social and environmental determinants of health – clean air, safe drinking water, sufficient food and secure shelter. Conversely, activities that promote human health, such as medical procedures, can have damaging effects on the environment. The One Health approach advocates sustainable healthcare policies where protecting the environment is considered an

integral part of protecting human health. This requires balancing benefits and risks to humans, to non-human animals and to our shared environment.

### **Biosafety**

Outbreaks of viruses such as COVID-19, Zika and Ebola have highlighted the role of high-containment biosafety laboratories in public health responses. Such laboratories are involved in the characterisation of human and animal pathogens, assist in disease surveillance, and conduct pre-clinical research that sustains the pipeline for development of diagnostics, therapeutics and vaccines. Biosafety laboratories carrying out high-risk research of this kind face challenges around safety compliance and dual-use. However, where biosafety laboratories are in short supply or non-existent, this can cause a major bottleneck in the fight against disease. Where the response is driven by biosafety experts outside a country, they can be constrained by local customs and societal norms.

### **Meat alternatives**

There is growing interest and investment in plant-based and cultured meat alternatives that attempt to closely imitate meat produced from animals. The environmental profile of meat alternatives looks promising in some scenarios, but there is little independent evidence on the effects of large-scale production. Long-term studies are needed to assess the health implications of eating meat alternatives. The proportion of people willing to try plant-based and cultivated meat alternatives is increasing. The potential for meat alternatives to contribute to sustainable food systems should be considered within broader contexts and alongside a range of other potential solutions for achieving food sustainability. [Read our briefing note on meat alternatives.](#)

### **Biofuels**

Some practices surrounding the use of biofuels might be harming the environment, for example the burning of wood pellets and deforestation for the supply of pellets and vegetable oil-based fuels. Also, energy policies relating to biofuels in wealthy countries could be having deleterious effects in poorer countries, and there is concern that climate change policies might be over-reliant on technologies using biofuels. [Read our report on biofuels.](#)

### **Gene drives**

Gene drives are systems that bias the inheritance of a particular DNA sequence. Animal populations can be altered or suppressed by allowing a mutation or foreign gene to spread quickly through a population. This has potential applications in the control of disease vectors such as mosquitos, rodent pests, and invasive species. If released into the wild, organisms carrying gene drives may be hard to contain. If the technique has low efficiency, it could leave time for species to evolve resistance. There are calls for a global moratorium on gene drives, but so far these have been resisted.

### **Animal research**

The number of animals used in research continues to increase, largely due to the use of genetically modified (GM) mice, and research trends are making research on larger animals more frequent and complex. GM primates are currently being created



to study a number of conditions, including autism. Is it time to review the way in which research involving animals is being incentivised, carried out, regulated, replaced and shared? [Read our report on research involving animals.](#)

### **Genome editing in farmed animals**

Genome editing could enable modifications to be made in farmed animals that have previously not been feasible. Researchers are exploring producing cattle without horns to prevent harm to other cattle and handlers, and making pigs and chickens resistant to certain diseases. Research to make animals more productive and tolerant to heat are also being explored. What would be the implications of these developments for animal welfare, product safety, and human health, and would meat and dairy products from genome edited animals ever be widely accepted by farmers and consumers? Which farmers would have access to these technologies? Will it be possible to scale this up to commercially viable levels? It is also important to ask where genome editing techniques sit within wider conversations about sustainable farming. [Read about our report on genome editing in farmed animals.](#)

### **De-extinction**

Scientists are attempting to revive extinct animals and plants in the laboratory. For example, genome editing techniques are being used to try to create a hybrid of a woolly mammoth and Asian elephant. If de-extinction become possible, how would species be selected, and would it really have a positive effect on today's ecosystems?

## **Research ethics**

### **Participant-led research**

Research activities led by patients or volunteers, rather than professional researchers, are increasing in popularity. Research that is controlled by participants challenges the whole basis for traditional research ethics, which focuses on protecting participants from exploitation by researchers. Do traditional research ethics approaches need to adapt and change?

### **Culture of research**

Aspects of the culture of research, such as high levels of competition and perceptions about how researchers are assessed for jobs and funding, has been found to encourage poor research practices and hinder the production of high quality science. Wellcome, a major funder of research, has stated publicly that the emphasis on excellence in the research system is stifling diverse thinking and positive behaviours. Wellcome and other key UK bodies are rethinking research culture, particularly within academic institutions. Less is known about how the culture of research in commercial environments affects research practices and outcomes, yet the business sector is responsible for the majority of R&D expenditure. [Read our report on the culture of academic research.](#)

## **Research in areas of controversy**

Some areas of research are surrounded by broader political and social debates that can be hostile and antagonistic. Examples from the past and present include gender identity and sexual orientation, tobacco use, chronic fatigue syndrome, climate change and research involving animals. Researchers working in these areas have experienced verbal and physical abuse, misuse and discrediting of their work, and difficulty in attracting funding. Researchers might avoid these areas of research or reframe their research to avoid potentially controversial terms or concepts. Some have been forced to leave research altogether. As with all research, research in areas of controversy should involve appropriate stakeholders and be highly rigorous and transparent. [Read our work on the care and treatment of children and adolescents in relation to their gender identity.](#)

## **Equity in the development of medicines and therapies**

There are concerns that the current system of medical research and development, particularly commercial R&D, does not benefit patients equitably and is unduly influenced by factors other than patient need, such as profit. Areas that might be influenced negatively include the prioritisation and funding of research, data availability, and drug licensing. Publication bias in relation to the suppression of negative findings could affect patient safety, and there might be unfair distribution of risks and benefits, particularly in the area of precision medicine. [Read our briefing note on equitable access to COVID-19 treatments and vaccines.](#)

## **Brain surrogates**

Brain surrogates are being developed to facilitate research on human brain function. They include organoids grown from stem cells, preserved human brain slices, and human-animal chimeras. These new techniques might reduce the need for animal research, but raise questions about the nature of suffering, consciousness, humanness, and death.

## **Fetal tissue research**

Fetal tissue, resulting usually from elective terminations of pregnancy, is used in developmental genetics and medical research. The use of fetal tissue in research interacts with debates about the acceptability of abortion. There are questions about the status of a pre-viable fetus, and the ethics of not using tissue that could contribute to valuable research. In September 2018, the US Government announced it was discontinuing research using human fetal tissue. Ways of reducing the need to obtain fetal tissue, such as growing fetal cells *in vitro*, are in the early stages of development.

## **Embryo research**

Recent developments in embryo research raise questions about the continuing relevance of existing UK legislation for this field. Embryos cannot be kept or used after the appearance of the primitive streak. The primitive streak is to be taken to have appeared in an embryo not later than the end of the period of 14 days. However, research has shown that the primitive streak might emerge in embryos after 14 days of development. In 2021, the International Society for Stem Cell Research released new guidelines that allows lab groups, in countries where it is

legal, to apply to the regulators for permission to continue research past 14 days. The development of new embryo-like entities, such as SHEEFS (synthetic human entities with embryo-like features), raise further questions about whether current laws and guidelines require review. [Read our discussion paper on the statutory time limit for maintaining human embryos in culture.](#)

### **Synthesizing entire human genomes**

Researchers have synthesized entire bacteria in the lab, and the possibility of creating human cells from scratch is now being explored. The cells could be engineered to resist viruses, radiation, freezing, ageing and cancer, and would be a valuable resource for research. Such a development would raise significant ethical and philosophical questions about the nature of life, parenthood, and scientific hubris.

### **Clinical research in pregnancy**

There is an increasing recognition of the need to include pregnant women in clinical research. During pregnancy, participation in clinical trials can support the development of effective and safe treatments for both women and fetuses. When conducting clinical research with pregnant women, ethical challenges include how to balance the interests of the woman and the fetus in research contexts, considerations of how perceptions of vulnerability might affect inclusion in clinical trials, and ensuring the voices of women are heard in matters concerning research during pregnancy.

### **Military biomedical research**

Military biomedical research has historically driven technological progress and medical advances, with important applications for civilian society. For example, military research programmes have made significant contributions to vaccine development and advances in surgery. Today, military biomedical research is increasingly looking at genetic engineering, neuroscience, and at intersections with other disciplines, including artificial intelligence and supercomputing, with the aim to enhance soldier ability and performance. Conditions unique to the military can make it difficult to obtain informed consent and conduct controlled clinical trials of emerging therapies. How can military biomedical researchers conduct their work in an ethically responsible manner?

### **Biotechnological patents**

Biotechnological patents can incentivise innovation in research fields including medicine, energy, and agriculture. However, the patenting of biotechnological innovations can also have negative consequences, such as disincentivising innovation for products that are likely to return lower profits, excessive development of similar products, and a focus on drugs and therapies for diseases that affect people in wealthy countries. There is an ongoing campaign to temporarily waive intellectual property protection on coronavirus vaccines as a step towards more equitable distribution. [Read our policy briefing on fair and equitable access to COVID-19 treatments and vaccines.](#)