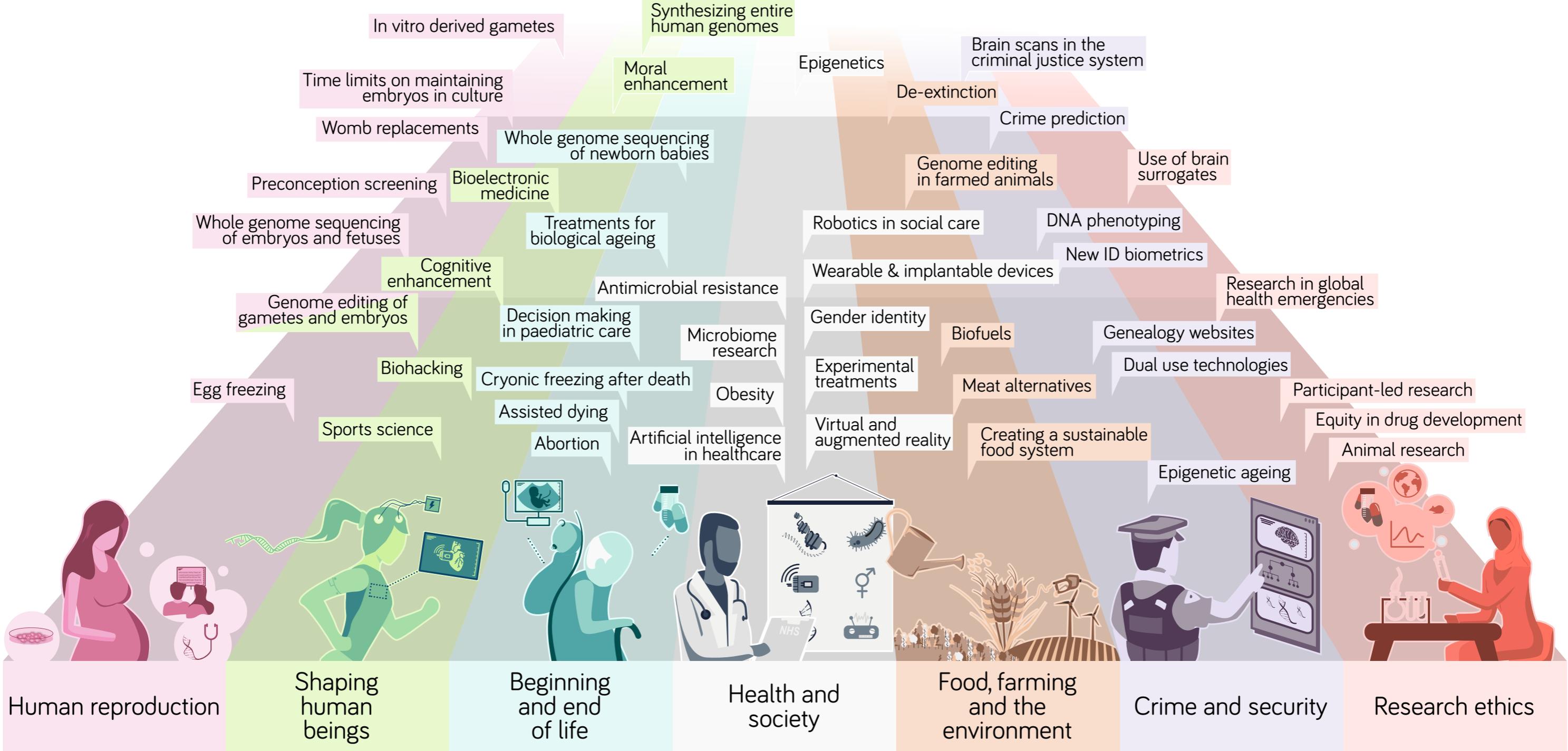


# WHAT'S ON THE HORIZON FOR BIOETHICS?



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## Human reproduction

### Egg freezing

The number of women choosing to freeze their eggs is growing rapidly, and some companies are already offering egg freezing as an employee benefit. This trend is likely to continue, but IVF with frozen eggs has a low success rate. Should we be worried about women feeling coerced into freezing their eggs, and what could be the knock-on social effects of this trend for women?

### Genome editing of gametes and embryos

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. A Chinese researcher has claimed that gene-edited twin girls have already been born. This is currently illegal in the UK. Before it can be permitted, 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.

### Whole genome sequencing of embryos and fetuses

Pregnant women and couples can have prenatal screening for several genetic conditions in the first trimester of pregnancy. Embryos can undergo pre-implantation genetic diagnosis 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. Will this have real benefits for health, or simply create confusion and worry for parents, and is it ethical to obtain and store this information without the child's consent?

### Preconception screening

Couples with a family history can have genetic testing before they conceive to find out if they are carriers for conditions like cystic fibrosis. 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. Should there be limits on what people can test for?

### Womb replacements

Researchers have kept premature lambs alive in artificial wombs for several weeks. This technology might help improve outcomes for premature human babies in future. Looking further ahead, when 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?

### Time limits on maintaining embryos in culture

UK law, set in 1990, states that human embryos cannot be kept or used for research for longer than 14 days. Recent research showed that it might now be possible to sustain embryos for longer, raising questions about whether the time limit should be extended. New entities, such as SHEEFS (synthetic human entities with embryo-like features), add to questions about the continuing relevance of the law.



### **In vitro derived gametes**

Mouse sperm and eggs cells can be created in the lab from other cells in the mouse's body, resulting in fertile offspring. This could become possible for humans in future, offering a new kind of fertility treatment for couples who cannot conceive and overcoming the shortage of eggs for research. It could also increase the risk of children being produced without one of the parent's consent or knowledge, and raises questions about what ethical significance ought to be placed on genetic parenthood.

## **Shaping human beings**

### **Sports science**

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?

### **Biohacking**

Biohackers apply the hacker ethic to change or enhance the human body, using 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 harming themselves, and do they pose a threat to national security?

### **Cognitive enhancement**

New drugs and techniques, such as transcranial magnetic stimulation, that might enhance cognitive function are being explored in a range of contexts, including education, military, employment and sport. Would this give some people an unfair advantage, and is this cheating or 'playing God'?

### **Bioelectronic medicine**

This emerging area of research uses implanted devices to read and modulate the electrical activity within the body's nervous system for the purposes of diagnosis or treatment of neurological disorders and chronic conditions. There is also interest in using the technology for improving the efficiency of military personnel. The techniques could be used to inflict pain without visible harm to an individual and raise issues relating to privacy, identity and autonomy.

### **Moral enhancement**

Could and should we intervene in the biological bases of human motivation, using drugs, genetic selection or neurotechnologies, to enhance our sense of morality? Some philosophers suggest that moral enhancement is necessary for tackling the major challenges facing society.

### **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, aging 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.



## Beginning and end of life



### **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.

### **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 particularly from the medical profession. MPs rejected an Assisted Dying Bill in 2015, but the debate is likely to return to Parliament in future.

### **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 low. However, there is little regulatory oversight and, if revival was achieved, it would raise complex questions about the nature of consciousness and identity, and our understanding of the nature of death.

### **Decision making in paediatric care**

There have been several recent high-profile cases of healthcare teams and parents disagreeing about the care of critically ill children in the UK. 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. Are there ways in which disagreements such as these can be avoided, or resolved more quickly?

### **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. 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.

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

In future, the parents of all newborn babies might be offered whole genome sequencing to identify their baby's risk of developing disease and to create a genetic data resource for life. This is likely to be available in the near future to parents through commercial genetic testing companies. Will this have real benefits for health, or simply create confusion and worry for parents, and is it ethical to obtain and store this information without the child's consent?

## Health and society

### Artificial intelligence in healthcare

A wide range of applications of AI are being explored with considerable public and private investment and interest. AI is being used or trialled for detection 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.

### Virtual and augmented reality

VR and AR that emulate or modify perceptions of reality have a number of potential applications in healthcare, eg pain management, psychotherapy, rehabilitation and training. Might this lead to an invasion of privacy if not used in controlled environments, and is there the danger that virtual environments could be too realistic, causing confusion between real and virtual worlds?

### Obesity

Levels of obesity across the population continue to rise. If they are to be effective, public health interventions of the future might need to go further than public information campaigns, banning fast food advertising, and taxing sugar. What level of state intervention and intrusion in a very personal area of life will be acceptable to people?

### Experimental 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 and crowdfund experimental treatments online, a key challenge will be respecting the interests and autonomy of patients while ensuring they are protected from harm.

### 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 about privacy and the nature of individual responsibility for health.

### Gender identity

Increasing recognition of people with non-traditional 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 to alter sexual characteristics be made available?

### Antimicrobial resistance

Increasing levels of antimicrobial resistance is a major global issue affecting health, agriculture, and the economy. There are serious implications for future generations. Interventions that aim to limit antimicrobial resistance might affect people unevenly across the world, reduce farming yields and increase food costs, and require the restriction of individual liberty.



### **Wearable & implantable devices**

Current and potential uses of wearable and implantable devices include monitoring health conditions, restoring function, self-tracking, tracking others, identification, sensory extension and communication. People who have implanted devices are sometimes referred to as cyborgs. There are concerns about the tracking or monitoring of individuals and the use of technologies in contexts of imbalanced power relationships, such as employment or education.

### **Robotics in social care**

Care robots could be looking after people in their own homes in future, reducing the burden on social care services. Will robots be reliable enough to look after our most vulnerable citizens safely, and will this lead to a dehumanising of care?

### **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.

## **Food, farming and the environment**

### **Creating a sustainable food system**

The production, transportation, and consumption of sustainable food should take into account effects on the environment, economy, human health, resource efficiency, food quality and safety, nutrition security, and animal welfare. Science and innovation that seeks to increase the sustainability of food in different ways could play an important role. Political, economic and social drivers are likely to have a strong influence on how this area develops.

### **Meat alternatives**

The consumption of meat and animal-derived products is likely to play a prominent role in broader debates about food sustainability, animal welfare, and health. Alternatives to meat include in vitro produced meat and non-animal diets, but will they be acceptable to consumers and economically viable?

### **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 biofuel-using technologies.

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

Genome editing could enable modifications to be made in farmed animals that have previously not been possible. Will it be possible to scale this up to commercially viable levels, what would be the effect on animal welfare, and would it ever be widely accepted by farmers and consumers?



## De-extinction

Scientists are attempting to 'revive' extinct animals and plants in the lab. 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?

## Crime and security



### Epigenetic ageing

Tests that analyse a person's 'epigenetic clock' are becoming more accurate at estimating a person's chronological age. There are potential applications in areas where the age of a person is important, for example assessing asylum seekers and refugees, or in disaster situations. This makes this area of research highly political and sensitive, and one where the accuracy of the test will be crucial.

### 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 warfare. Do some new technologies, such as synthetic biology and neurobiology, prompt particular concerns about dual use?

### Genealogy websites

Popular genealogy websites, such as 23andme, are emerging as a new resource for criminal investigators. Although many support the use of any means available to find and prosecute perpetrators of serious crime, some are worried about 'mission creep' and people's data being used for purposes they did not consent to.

### New ID 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, e.g. solving crime?

### 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. However, 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 invasion of privacy.

### Crime prediction

Crime data can be analysed to make predictions about where a crime will take place, allowing police resources to be deployed in advance. It's not yet clear if crime prediction reduces crime, and there are worries that biases in the data could reinforce police prejudices about particular areas and ethnic minorities.

### **Brain scans in the criminal justice system**

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 and 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.

## **Research ethics**

### **Animal research**

The number of animals used in research continues to increase, largely due to the use of GM mice, and research trends are making research on larger animals more frequent and complex. Is it time to review the way in which research involving animals is being incentivised, carried out, regulated, replaced and shared?

### **Equity in drug development**

There are concerns that the current system of drug development and research 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, patient safety, and drug licensing.

### **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?

### **Research in global health emergencies**

Recent emergencies, such as the Ebola epidemic in Africa, have highlighted the important role of research in the humanitarian response. However, a lack of consensus on what is ethically acceptable during emergencies could be impeding the progress of valuable research, and adding to the risk that research might be carried out in unethical ways.

### **Use of brain surrogates**

Brain surrogates are being developed to facilitate research on human brain function, including 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.

