

Genetic engineering/ Editing humanity

A new technique for manipulating genes holds great promise—but rules are needed to govern its use

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THE genome is written in an alphabet of just four letters. Being able to read, study and compare DNA sequences for humans, and thousands of other species, has become routine. A new technology promises to make it possible to edit genetic information quickly and cheaply. This could correct terrible genetic defects that blight lives. It also heralds the distant prospect of parents building their children to order.

The technology is known as CRISPR-Cas9, or just CRISPR. It involves a piece of RNA, a chemical messenger, designed to target a section of DNA; and an enzyme, called a nuclease, that can snip unwanted genes out and paste new ones in. Other ways of editing DNA exist, but CRISPR holds the promise of doing so with unprecedented simplicity, speed and precision.

A dizzying range of applications has researchers turning to CRISPR to develop therapies for everything from Alzheimer's to cancer to HIV . By allowing doctors to put just the right cancer-hunting genes into a patient's immune system, the technology could lead to new approaches to oncology. It may also accelerate the progress of gene therapy—where doctors put normal genes into the cells of people who suffer from genetic diseases such as Tay Sachs or cystic fibrosis.

It will be years, perhaps even decades, before CRISPR is being used to make designer babies. But the issues that raises are already the subject of fierce discussion. In April scientists in China revealed they had tried using CRISPR to edit the genomes of human embryos. Although these embryos could not develop to term, viable embryos could one day be engineered for therapeutic reasons or non-medical enhancement.

That is a Rubicon some will not want to cross. Many scientists, including one of CRISPR's inventors, want a moratorium on editing "germ line" cells—those that give rise to subsequent generations. America's National Academy of Sciences plans a conference to delve into CRISPR's ethics. The debate is sorely needed. CRISPR is a boon, but it raises profound questions.

The only way is ethics

These fall into two categories: practical and philosophical. The immediate barrier is practical. As well as cutting the intended DNA, CRISPR often finds targets elsewhere, too. In the laboratory that may not matter; in people it could cause grave harm. In someone with a terrible disease, the risk of collateral damage might be worth running. But for germ-line applications, where the side-effects would be felt in every cell, the bar should be high. It may take a generation to ensure that the technology is safe. Until then, couples with some genetic diseases can conceive using in-vitro fertilisation and select healthy embryos.

Moreover, awash though it is with gene-sequence data, biology still has a tenuous grip on the origins of almost all the interesting and complex traits in humanity. Very few are likely to be easily enhanced with a quick cut-and-paste. There will often be trade-offs between some capabilities and others. An à la carte menu of attributes seems a long way off. Yet science makes progress—indeed, as gene sequencing shows, it sometimes does so remarkably quickly. So scientists are right to be thinking now about how best to regulate CRISPR.

That means answering the philosophical questions. There are those who will oppose CRISPR because it lets humans play God. But medicine routinely intervenes in the natural order of things—saving people from infections and parasites, say. The opportunities to treat cancer, save children from genetic disease and understand diabetes offer justification to push ahead.

A harder question is whether it is ever right to edit human germ-line cells, to make changes that are inherited. This is banned in 40 countries and restricted in many others. There is no reason for a ban on research or therapeutic use: some countries, rightly, allow research on human embryos, as long as they are left over from in-vitro fertilisation and are not grown beyond 14 days; and Britain has allowed a donor to supply mitochondrial DNA at conception to spare children needless suffering, even though the change will be passed on. And CRISPR deals with the objection that germ-line changes are irrevocable: if genes can be edited out, they can also be edited back in.

A deeper quandary concerns the use of CRISPR to make discretionary tweaks to a person's genome. There comes a point where therapy (removing genes that make breast cancer or early-onset Alzheimer's more likely, say) shades into genetic enhancement. Some might see being short or myopic as problems that need fixing. But here, too, the right approach is to be cautiously liberal: the burden is on society to justify when and why it is wrong to edit the genome.

CRISPR, happier, more productive

It is not too soon to draw on these principles to come up with rules. Some countries may have gaps in their legislation or poor enforcement, letting privately funded scientists or fertility clinics carry out unregulated CRISPR research. The conservative, painstaking approach taken by Britain's Human Fertilisation and Embryology Authority in its decision on mitochondrial

DNA is a model. Regulators must also monitor CRISPR's use in non-human species. Changing animals' genomes to spread desirable traits—mosquitoes that cannot transmit malaria, for example—could bring huge benefits. But the risk of unanticipated consequences means that such “gene drives” should be banned unless they can be reversed with proven countermeasures.

If CRISPR can be shown to be safe in humans, mechanisms will also be needed to grapple with consent and equality. Gene editing raises the spectre of parents making choices that are not obviously in the best interests of their children. Deaf parents may prefer their offspring to be deaf too, say; pushy parents might want to boost their children's intelligence at all costs, even if doing so affects their personalities in other ways. And if it becomes possible to tweak genes to make children smarter, should that option really be limited to the rich?

Thinking through such issues is right. But these dilemmas should not obscure CRISPR's benefits or obstruct its progress. The world has within its reach a tool to give people healthier, longer and better-quality lives. It should be embraced.