

Should we...?

Ten scientific dilemmas
that will shape our future



DAVID DE LAS HERAS

Minimising suffering. Maximising happiness. Saving the planet. Looking after future generations. Worthy goals all, but what happens when they come into conflict?

Science and technology are constantly pitting our values against each other. In this special feature, we've selected 10 particularly burning dilemmas. What makes them so thorny, what ethical principles are at stake – and what should we do?

SHOULD WE... GIVE OTHER ANIMALS RIGHTS?

Minimise suffering of other life forms

VS

Maximise human well-being

For centuries, if not millennia, ethical debates have centred on the notion that human beings have certain fundamental, inalienable rights. No matter what you do, or how evilly you behave, those rights cannot be stripped away. Even if violating your rights would turn out to be for the common good, tough luck – they're there to stay.

But the question of what other animals should benefit from such blanket protections is an open one. Last November, an Argentine court endowed a chimp called Cecilia with the right to live in her natural habitat and ordered her release from Mendoza zoo. Six months later, a Canadian court upheld the notion that pigs are property that can be denied food, water or rest in transit for up to 36 hours.

So what should qualify? If our objective is to minimise suffering in any fellow creature, is it time to give non-human animals rights on a par with our own? Should the intelligence of an octopus exempt it from being hunted and eaten by humans? Does the same go for pigs? Are mice entitled to freedom of movement?

The short answer is, it's complicated. "There are different kinds of rights," says Andrew

Knight, who studies animal welfare and ethics at the University of Winchester, UK. "Although sentient animals should have key moral rights respected, it makes no sense to give them the same legal rights as humans."

Chimpanzees provide a salient example of the problem. They have had their rights championed more than most: it is now illegal in many countries to do scientific experiments on them, and efforts are under way to grant them personhood – effectively, human rights. But Jennifer Mather, an animal behaviour expert at the University of Lethbridge, Canada, sees no reason why chimps should receive such privileged status. "Animals from all taxa deserve consideration," says Mather, although she admits others may disagree.

"I am all for working towards improved welfare of animals, but that doesn't mean ascribing them rights," says Steven Cooke at Carleton University in Canada. "I care far more about ensuring that we properly manage populations and habitats to ensure resilience and enable appropriate human use," he says (see "Should we colonise other planets?", page 35).

The truth is that most of modern life, from clothing manufacture to agriculture, relies on exploiting animals and treating them with less regard than humans – especially if they invade our space.

The calculus is a complex one. Would mosquito rights lead to the end of eradication programmes and thus the spread of malaria? Would horse or cattle rights force humans to take up gruelling physical labour? "It's a moral and ethical dilemma – my view is that we have the right to use animals but should do it humanely," says Lynne Sneddon, an animal welfare researcher at the University of Liverpool, UK.

Wider education about animals' experience is the primary way forward, Mather says. She thinks an understanding of animal sentience, such as the problem-solving skills of crows, the self-awareness of elephants and the theory of mind demonstrated by chimps, will help us achieve a more sophisticated stance. "As we discover more and more about how animals are smart, it is going to be easier to see that they should have some basic consideration."

Michael Brooks

GENETICALLY ENGINEER OUR CHILDREN?

Maximise human well-being

VS

Respect difference

The thought of shaping future generations to fit some pre-imagined ideal of strength and beauty is one that should make us uncomfortable. Once a fashionable field of enquiry, the study of eugenics remains associated with some of the worst excesses of the 20th century, from forced sterilisation to genocide. The lesson we might be tempted to draw from this is to let nature proceed unchecked, free from human meddling, and embrace the diversity it engenders.

But as ethically comforting as that sounds, deciding to do nothing is a decision in itself. We may like to think of humans as perfect, finished natural products that should not be interfered with, but nature's creations are botch jobs, full of mindless mistakes. And evolution's way of getting rid of the worst mistakes is to let children suffer horribly and die young.

In the interests of human well-being, then, should we head back down the slippery slope?

Actually, we already have. In most countries, it is already legal to shape the genomes of our children in various ways, from the abortion of fetuses with Down's syndrome to the screening of embryos during IVF. Last year, the thin end of the wedge got that little bit thicker when the UK gave the go-ahead for what have been called "three-parent babies", whose mitochondrial DNA is supplied by a third-party donor.

And now, thanks to the revolutionary genome-editing method known as CRISPR, we can directly edit the main genome of cells. In theory, CRISPR could be used to weed out the hundreds of mutations that make us more likely to suffer from disorders ranging from heart attacks to cancer to Alzheimer's to schizophrenia, greatly improving the health of future generations.

From this perspective, it appears immoral not to genetically improve our descendants in every way we can. "There is a moral imperative," says ethicist Julian Savulescu of the University of Oxford. "We would be

horrified if a child went deaf because the parents refused drugs or surgery. It is just as wrong, argues Savulescu, not to use gene editing once it is safe to do so.

Some see it very differently. Gene editing could be a way of "disappearing" certain types of people, suggested actress Kiruna Stamell, who has a rare form of dwarfism, at a recent debate. "By eradicating individuals with the condition, we are not beating the condition, we are not curing it."

The issue is whether some states we regard as disabilities are just differences that are only a problem because the rest of society treats them as such (see "Should we make everyone 'normal'?", right). For Savulescu, conditions like deafness, blindness and paraplegia are disadvantageous no matter what. "If you can correct them, then you should."

These are questions our descendants may grapple with for millennia to come. Barring scenarios in which we merge with machines to become superhuman cyborgs, it seems certain we will increasingly shape the genomes of our children. The only question is how. **Michael Le Page**

"Gene-editing could be a way of 'disappearing' certain types of people"

MAKE EVERYONE 'NORMAL'?

Respect difference

VS

Maximise human happiness

Imagine a pill or therapy capable of rewiring your neural circuitry so as to make you more empathetic: one that decreases aggression, and causes your capacity for moral reasoning and tendency to forgive to go through the roof. Wouldn't the world be a better place if we were all encouraged to have it? In fact, if human happiness lay on the other side of a tablet, why not embrace utopia and prescribe it by force?

Such a scenario may not be as far away as you suppose. Technologies to read and manipulate thought patterns are growing. Elon Musk's Neuralink project is attempting to establish direct communication between our brains and computers, while Kernel, a company in California, has invested \$100 million to develop intelligence-boosting brain implants. Electric shocks delivered to the brain have been found to combat depression, and certain chemicals can help us make more moral decisions.

But even if weeding out aberrant thought patterns and enforcing social conformity through technological or pharmacological means could be made to work in practice, would it be the right thing to do? Or do people have an inalienable right to be themselves, provided they pose no immediate risk to themselves or others?

"This is a topic we need to be talking more about right now," says Chris Danforth, co-director of the Computational Story Lab at the University of Vermont. Letting the majority of the population redesign the outliers in the interests of their own safety might seem to do the greatest good for the greatest number of people, but opens the door to some terrifying possibilities. Historically, those who challenged the status quo saw their motivations recast as mental deviancy - such as Victorian women confined to asylums for rebelling against patriarchal society, or gay men like Alan Turing who were given the "choice" of chemical castration.

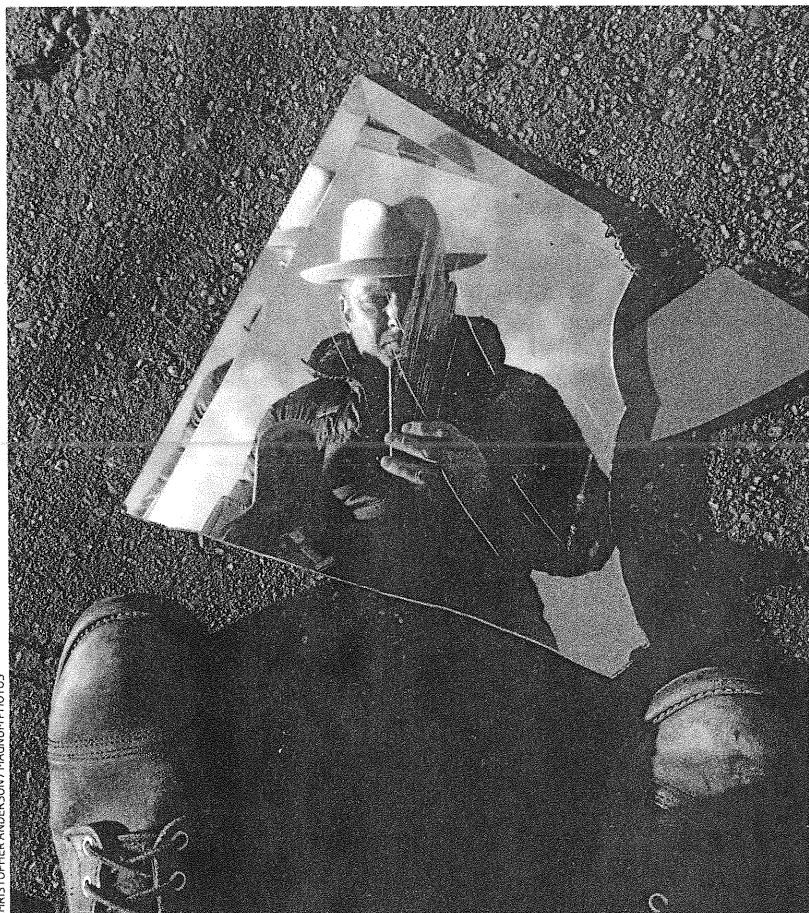
"Being normal is a dangerous concept," says Mark Slater, a consultant psychiatrist and spokesperson for the Royal College of Psychiatrists in London. "How can we evaluate happiness or contentment, or a specific blood pressure come to that, as normal?" Not only is "normality" an illusory concept, but our conception of it is ever-changing. If we began to optimise people for the qualities we wished to see

SHOULD WE...

in society, who gets to choose what those are?

Perhaps conformity isn't as good for society as we suppose. In 2015, psychologist Jesse Harrington at the University of Maryland published a study showing that highly restrictive societies fared worse in measures of overall happiness, rates of depression and suicide than moderate ones - but then again, so did highly permissive cultures. When it comes to how much abnormality we should tolerate, then, it seems we would be best off having the normal amount. Frank Swain

"Conformity may not be so good for society as we suppose"



CHRISTOPHER ANDERSON/MAGNUM PHOTOS

ABANDON PRIVACY ONLINE?

Maximise human happiness

VS

Maximise human safety

Those who would give up essential Liberty to purchase a little temporary Safety," Benjamin Franklin once said, "deserve neither Liberty nor Safety." But if Franklin were alive today, where would he draw the line? Is the freedom to send an encrypted text message essential? How about the right to keep our browsing history private? What is the sweet spot between our need to be left alone and our desire to keep potential criminals from communicating in secret?

In an age where fear of terrorism is high in the public consciousness, governments are likely to err on the side of safety. Over the past decade, the authorities have been pushing for - and getting - greater powers of surveillance than they have ever had, all in the name of national security.

The downsides are not immediately obvious. After all, you might think you have nothing to hide. But most of us have perfectly legal secrets we'd rather someone else didn't see. And although the chances of the authorities turning up to take you away in a black SUV on the basis of your WhatsApp messages are small in free societies, the chances of insurance companies raising your premiums are not.

The Faustian bargain taking place in our interactions with tech companies has gone more or less unnoticed. We hand over our data and in return get to use apps and websites without charge, with virtually no insight into how our information gets used, or who it gets sold on to. People have been declaring the privacy debate over for 20 years, says Paul Bernal at the University of East Anglia Law School in Norwich, UK. In fact, it's a debate we've never actually had. And the ethical issues at its heart are getting more urgent, not less. "What this is really about is interfering with people's lives," says Bernal.

Recent allegations of political manipulation in the Brexit and Trump campaigns give a glimpse of the dangers. According to reports, UK company Cambridge Analytica used psychometric profiling based on publicly

They're
watching
you

GIVE ROBOTS THE RIGHT TO KILL?

Maximise human safety

VS

Keep technology under control

available data, including Facebook “likes”, to present finely tuned personalised ads to undecided voters. It’s not clear they had any effect, but the method is based on research that shows you can profile people surprisingly accurately using just public social media activity.

And while we don’t have to use any of these services, the likes of Facebook, Google and Amazon are so dominant that it has become hard to find alternatives. In many newly connected countries there aren’t any. Myanmar, for example, was largely offline until a few years ago; now it has one of the highest proportions of Facebook users in the world. For most people there, Facebook is the internet and its approach to privacy the norm. “Ethically, it’s a critical issue,” says Bernal.

Of course, data-fuelled technology could also bring enormous benefits, improving the way we treat disease, manage energy use and run communities. But the issue is who gets our data, and what do we want them to do with it? Personal data is knowledge and knowledge is power. “In the end, it comes down to a slow erosion of our autonomy,” says Bernal. “We need to step back and talk about what kind of control we’re giving away. What are the final consequences and are they acceptable?”
Douglas Heaven

“It is morally wrong to give autonomy to robots that cannot think morally”

Hot-headed, irrational and swayed by emotion - who’d want a human in control? If we could build machines capable of making tough choices for us, surely we should. That’s the line taken by people like roboticist Ron Arkin at the Georgia Institute of Technology in Atlanta. For Arkin, autonomous weapons - or killer robots - that remain rational under fire and behave exactly as they were trained to would be more humane than human soldiers in a war situation, and would save lives. We therefore have a moral imperative to create them.

The same reasoning can be applied to many scenarios where human nature may stop us doing the right thing, from driving to making life-or-death decisions in hospitals to criminal sentencing. Computers are already moving into all these areas, and in many cases surpass humans where it counts. But how much autonomy should we give them?

The problem with fully autonomous machines from a moral point of view is that they cannot take responsibility for their actions. Human ethics is built on the assumption that actions are done by agents with the capacity to make a call between right and wrong. If we offload those actions on to machines, who do we blame when something goes wrong?

Filippo Santoni de Sio, a philosopher and ethicist at the Delft University of Technology in the Netherlands, calls this the “responsibility gap”. For him, it is crucial that a human always takes responsibility. This might be the machine’s designers or a designated human handler, much as a parent takes responsibility for their child or an owner for their pit bull. “It is morally wrong to give autonomy to machines because they cannot perform moral thinking,” says Santoni de Sio.

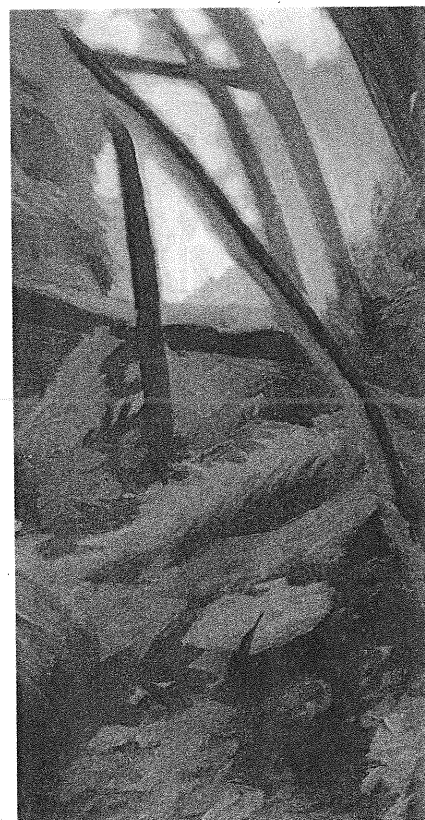
Arkin and others have suggested that at some point in the distant future machines capable of moral reasoning could be built. But even in such a case, many will still feel it is wrong to delegate such decisions to a machine. With people, we don’t just want them to do the right thing; we also have a need to understand why they act the way they do.

Blame is as much about explanation as it is compensation or retribution, says Santoni de Sio. “This is the main idea behind moral responsibility - we want to blame people not necessarily because

we want to punish them, but because we want to understand. We want to see the person’s face, we want to ask questions.”

So where do we go from here? Where the stakes are highest, many are calling for an outright ban. Campaigners are pushing the UN to draw up a treaty curbing development of autonomous weapons, for example. Legislation is on its way for autonomous vehicles too. Germany has proposed a highway code for driverless cars, laying down guidelines for who is ultimately responsible in an accident. And similar regulations will be drawn up for medical robots.

Attitudes may change as we work through the moral maze surrounding autonomous machines. But for now, at least, we will be keeping them on very short reins. Douglas Heaven



SHOULD WE...

RELEASE SYNTHETIC LIFE FORMS INTO THE WILD?

Keep technology under control

VS

Save the planet

B iologist George Church is making forms of life that could never arise naturally. He and his team are changing the genetic code of *E. coli* bacteria used in drug manufacture so as to make them immune to all viruses: a giant step forward for the industry. But the very immunity that serves us so well in a vat in the lab could come back to bite us if those bacteria wound up in our bodies.

Church's team at Harvard University is just one of hundreds around the world creating "synthetic life", some kinds meant for labs and factories, others for farms. Can we really control these creations? Can we ensure they remain where we want them? Or do the potential risks

to us and to wildlife mean it would be better not to meddle with synthetic life at all?

"Biocontainment is our number one priority," Church told *New Scientist* last year when he unveiled his latest creation. To ensure his recoded organisms cannot go feral, he has altered them so they are dependent on chemicals that don't occur naturally.

Others want to go much further, creating forms of life based on molecules not used by any other organism. With an entirely different biochemistry, such truly synthetic life would pose little risk – at least in theory.

But less alien forms of synthetic life are already common. Many drugs are now produced by modified cells, for instance, and more than a tenth of arable land is planted with genetically modified crops.

Such technology is still in its infancy, but the potential benefits are huge. For instance, creating plants better at photosynthesising would let us grow more food on less land. That means more land could be set aside for wildlife, or used for capturing carbon (see "Should we geoengineer the planet?", page 34). This could be crucial in a world where land is in increasingly short supply.

But plants that can capture more of the sun's energy would be able to outcompete ordinary ones. Supercrops that combine several beneficial traits, such as enhanced photosynthesis, and resistance to salt, droughts, viruses and pests, would be even more likely to turn into rogue superweeds.

And our track record on biosafety is not exactly reassuring. Genetically modified plants and products keep being found in places they are not meant to be, and lab accidents are still distressingly commonplace.

In an ideal world, perhaps it might be better not to take the risk. But in our world, with looming crises from population growth to climate change, it looks as if we have no choice.

If we lose that gamble and synthetic life does take over the world, who knows: it might do a better job of caring for the planet than we have. **Michael Le Page**

HELP! WHAT SHOULD WE DO?

At times, making the ethically right decision can seem impossible. Every course of action is bound to benefit one group at the expense of another, whether it's people on the other side of the world or future life forms on a distant planet. So how do we decide what to do?

For Elinor Mason, an ethicist at the University of Edinburgh, UK, the key is to not let ourselves get distracted by the quest for the perfect answer. Imagine we are repainting our house and have to decide on a single colour, says Mason. "We're not going to interrupt ourselves halfway through and say, 'isn't this all just a matter of opinion?' We have to decide and move forward."

For Andrew Stirling, a science policy researcher at the University of Sussex, UK, making the best possible decision depends on three key principles: responsibility, precaution and participation. First, experts have a responsibility to drop the pretence that they can be perfectly impartial. We all have a moral perspective, and our collective decision-making only benefits if those perspectives are shared freely.

Second, we have to proceed with caution, as the uncertainties surrounding alternative futures are far too complex to be easily comparable. The fiction that one scenario can be deemed superior to another on the basis of the facts alone is reassuring to policy-makers, but does the rest of us a disservice.

And finally, all members of society should have the chance to participate in debates like the ones outlined on these pages. "We shouldn't be scared about involving ordinary people in decisions about science and technology," says Stirling. "The technologies we pursue, the innovations we support, the sciences we prioritise, are as genuine matters for democratic discussion as anything else."

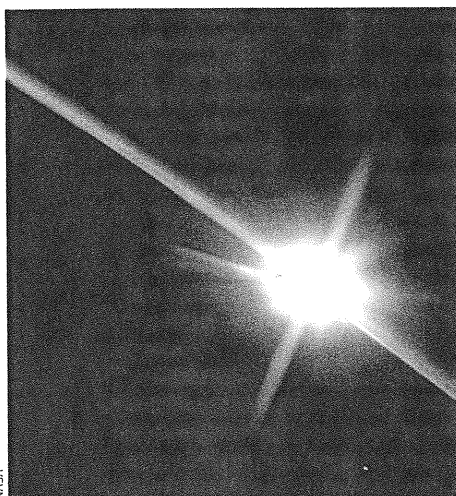


ENGINEER
EARTH?

Save the planet

VS

Look after future generations



NASA

The pressure is on. If we want to save the planet from the worst effects of climate change, we need to get our greenhouse gas emissions to zero by 2070 - a target that requires immediate and drastic action. But our unbreakable addiction to fossil fuels makes this goal seem more and more unreachable. So what if there were another solution, some quick techno-fix that could let us burn our fuel but not our planet?

Enter geoengineering: large-scale manipulations of the planet designed to clean up our mess. The ideas range from sucking carbon dioxide out of the atmosphere to deploying a stratospheric parasol that would bounce the sun's warming rays back out into space. Some have been field-tested, or soon will be. But while most climate researchers agree geoengineering makes sense as a last resort, we need to ask: do we have the right to interfere with the planet on this scale?

The answer might seem obvious: we've already done it. By chucking billions of tonnes of greenhouse gases into the atmosphere, humanity has put the planet's thermostat on turbo-boost, melted the Arctic, and altered the seasons, large-scale weather systems and the ocean's acidity. Why should reversing that be any different?

Opinions vary. "A strict consequentialist would argue that there is no ethical difference because

what is right is determined solely by the outcome," says Steve Rayner, a climate policy researcher at the University of Oxford. "However for most other ethical viewpoints, motives matter. They certainly matter in law."

To John Shepherd of the University of Southampton, UK, who led a Royal Society working group on geoengineering, the risks need to be put in context: "I find it hard to see that attempting to ameliorate climate change deliberately should be unacceptable in principle, so long as it was done carefully and cautiously, and with an exit strategy in place".

The various proposals carry different risks for different people. One contender involves covering vast areas with vegetation in order to suck CO₂ out of the skies and then be burned as fuel - with the resulting emissions buried deep underground. It may sound promising, but the new forests would have to compete for land with food crops, probably in tropical countries that have contributed least to global warming and will suffer most from it.

Sunshades also come with risks. Kevin Trenberth and Aiguo Dai of the US National Center for Atmospheric Research in Colorado looked at past mega-volcano eruptions, which release particles that reflect light in a similar way to proposed sunshades. They found that these events caused a marked decrease in precipitation, particularly in the tropics. Computer models have since confirmed that artificial sunshades would rapidly lower regional temperatures but also change rainfall patterns, resulting in poor harvests and the risk of drought.

Legacy is another major ethical concern. What goes up must come down and sunshades, like volcanic dust, will eventually be rained out. In the meantime, our continued appetite for fossil fuels would cause greenhouse gases to pile up in the atmosphere. If a future generation decided to stop maintaining the sunshade, the world would be hit with the full force of the resulting climate change. In the space of a few years, global temperatures would shoot up to where they should have been all along. The consequences for humanity could be disastrous.

Silver bullet, then, or Russian roulette? It may be that the only real solution is to find another one.

Catherine Brahic

IMPOSE POPULATION
CONTROLS?

Look after future generations

VS

Realise human potential

Fears that we are too many are nothing new. As long ago as 1798, the English writer Thomas Malthus warned that a growing population would eat its way through the planet's finite resources, condemning millions to die of starvation.

We haven't exhausted our supplies quite yet, but seven billion people later our planet's ability to support us all comfortably does appear to be under threat. If we all lived like affluent Americans, say, resource consumption and carbon emissions would be at unsustainable levels. Given the clear and present dangers posed by climate change, how can we look after future generations without keeping half of the world's population in poverty?

For Travis Rieder, a bioethicist at Johns Hopkins University in Baltimore, the answer is reducing birth rates - and not in the places you might expect. When it comes to climate change, says Rieder, "my American kid is way more problematic than the many children a family might have in poor, high-birth-rate countries". And should the worst consequences of climate change come to pass, it will be the poorest that suffer most severely. So let's assume that the West is incapable of slashing carbon emissions or finding a technological silver bullet

"If we all lived like affluent Americans, the impact would be unsustainable"

COLONISE OTHER PLANETS?

Realise human potential

VS

Minimise suffering of other life forms

(see “Should we geoengineer the planet?”, left). In this case, we are obliged to explore all options, including the taboo subject of population control. “It’s the one variable we haven’t been prepared to talk about, but if we could reduce fertility, it would have a powerful effect on emissions,” says Rieder.

Most people are uneasy about any intrusion on people’s right to choose how many kids they have. Rieder points out, though, our rights get limited by the interests of others all the time. Why should proactive rights be any different?

Historically, however, attempts to limit our numbers have often led to abuses. The stain of forced sterilisations and abortions performed to satisfy China’s one-child policy is hard to shift. But there are other, less extreme ways to encourage people to have fewer children, such as giving everyone access to the education and resources they need to make informed decisions. Few would argue against that.

More interesting is the middle ground. How about a tax on families with more than two kids, for example, incentivising people to change their preference? You would have to tread carefully, says Rieder, given the harm you could cause children by removing resources. And while public information campaigns sound less problematic in theory, the reality is not so clear-cut. As Rebecca Kukla at Georgetown University in Washington DC has pointed out, women are already widely held responsible for family size, so making it a moral issue would only add to their burden. If norms on family size shift, she says, you will see a backlash against women who have more children than is deemed responsible.

Then again, maybe we’re missing the point. If the problem is too many of us living at the same time, why not limit lifespan instead of birth rate? Billions of dollars are spent each year on research aimed at extending our lives, but those golden years are only making things worse for others. Perhaps the ethical thing to do would be to divert those funds elsewhere.

Daniel Cossins

Next stop, Mars. Space agencies and private companies alike plan to send humans to the Red Planet in the next decade, with the idea of permanent settlements twinkling in the future. As the technical challenges of such missions are conquered one by one, it’s past time to ask: is taking over another world the right thing to do?

This question, like so many ethical quandaries, comes down to rights: does life on other worlds have the same rights as Earth life? What if it’s just microbes? And what if there is no life at all? Do humans have the right to leave muddy bootprints on pristine planets, potentially stamping out future civilisations before they arise?

“There’s this idea lurking behind all of this that the universe has a natural way of doing things and that humans come in and mess it up,” says Kelly Smith, a philosopher at Clemson University in South Carolina. But, Smith says, humans are also part of the natural world, and not everything we do is bad, so a human settlement might enhance nature’s pristine splendour rather than ruin it.

That’s not to say we shouldn’t tread carefully. Even now, when we send spacecraft to hover near other worlds, we take great pains to ensure they are as clean as possible to avoid contaminating the planet or moon with Earth life. Of course, this consideration doesn’t arise out of respect for other worlds so much as the fear that it could render them useless for scientific study.

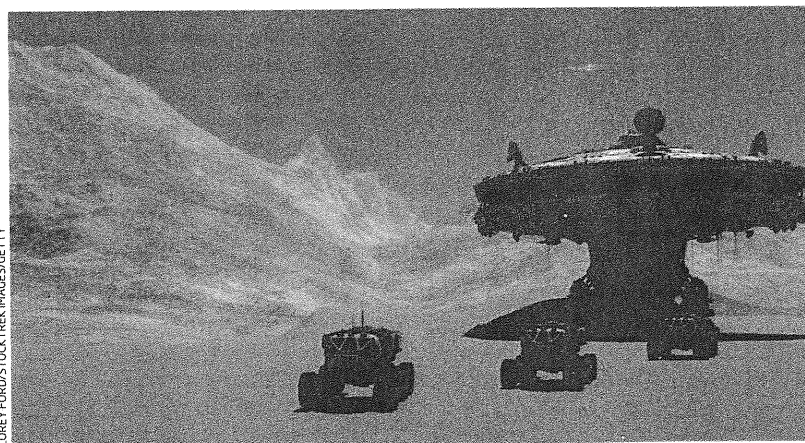
But settling humans on another planet would be a big step – make that a giant leap. Rather than mere contamination, it would probably mean overrunning or exterminating any native organisms outright.

Would that give us pause? On Mars, say, the most probable life forms are microbes. And when it comes to microbes on Earth, says Margaret Race, a biologist with the SETI institute in California, “we are killers, and deliberately so”, murdering them with pesticides, antibiotics and soap every day.

Once the excitement surrounding any discovery of extraterrestrial microbes had faded, their eradication would seem a small price to pay for an expansion of human civilisation. “If we did destroy Martian microbes to create a new human society on Mars, I would argue that what we created is a whole lot more valuable than what we lost,” says Smith.

That means we would have a responsibility to create a successful society, forcing us to take a hard look at the way we have changed and maintained our own world. “The idea that we could just take a whole planet and massively transform it to make it habitable for ourselves – gosh, we just did that and it’s not going so well,” says Maria Lane at the University of New Mexico.

If Earth becomes so uninhabitable that we need another planet as a lifeboat, what’s to say we won’t do the same again? Colonising the universe is all well and good, but not if we leave a trail of pillaged worlds in our wake. Leah Crane



Mind those microbes

COREY FORD/STOCK TREK IMAGES/GETTY

STOP DOING SCIENCE?

Realise human potential

VS

Everything else

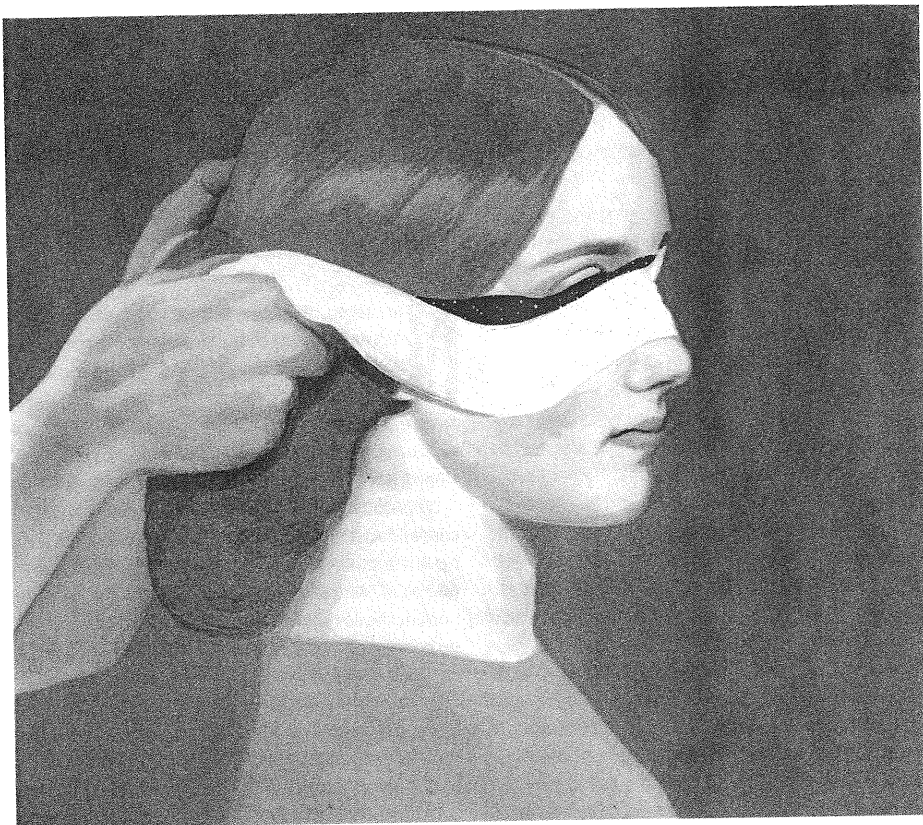
Science has the capacity to cure diseases, improve crop yields, reshape the planet and carry us into the cosmos, but is any of that worth the risks? The march of science has improved the lives of some, but not all. And it has inadvertently precipitated a problematic population explosion (see “Should we impose population controls”, page 34) and an unfolding environmental catastrophe. As Winston Churchill once said, “It is arguable whether the human race have been gainers by the march of science beyond the steam engine... Give me the horse.”

Add to that the development of weapons of mass destruction, disgraceful research such as the Tuskegee syphilis experiments on African Americans, and a few accidents such as the 1978 release of smallpox in Birmingham, UK, and perhaps the ethical thing to do would be to quit while we’re ahead. We have enough knowledge, surely?

Not according to Lewis Dartnell at the University of Leicester, UK. Having spent years assembling *The Knowledge*, a detailed handbook for rebuilding a scientific civilisation after an apocalypse, he thinks there is still plenty of room for more insight. Scientific exploration of the world around us is just what we do – and it has been the making of us, he reckons.

“Through it we serendipitously discover whole new areas of understanding, which then offers the means to build fundamental new kinds of technology,” Dartnell says. “I don’t think that anyone would argue that we would want to give up now and stop making these fundamental leaps in our understanding that are so helpful to the world.”

But philosopher Massimo Pigliucci of the City University of New York is willing to make that argument. He admits that a lot of applied science – medical research, for example – results in social benefit (see “Should we genetically engineer our children?”, page 30). But not all science can be applied, and maybe it shouldn’t all be funded, he suggests. The idea that scientists ought to pursue whatever



stimulates their curiosity because no one knows where the next practical application will come from is “really nothing more than a convenient just-so story”, Pigliucci says. “It is odd that a bunch of empirically minded people will not actually be able to produce empirical evidence supporting the idea of unqualified benefits of basic scientific research.”

“The biggest winner from science has been the military”

The elephant in the room, Pigliucci says, is that scientific and technological advances have allowed us to group into vast nations, and the biggest winner from that seems to have been the military complexes designed to keep one scientifically armed nation from massacring another. The money we spend on military science and its applications far outweighs all other “public interest” science spending, he points out. “Maybe, before questioning the relatively small amounts we spend on basic science, we should ask ourselves what on earth are we doing with such an oversized military?”

Whatever the pros and cons, we certainly won’t stop science at this stage of our civilisation, according to Jerry de Groot of the University of St Andrews in the UK. “It’s an intriguing idea, but I can’t see how it would remotely work in practice,” he says. What’s more, he adds, any forced scaling back would open science up to potentially disastrous manipulations. “Funding would be even more subject to political whim than it is now.”

Michael Brooks