GEOENGINEERING

Price of sucking CO_2 from air plunges

Technology moves closer to economic viability.

BY JEFF TOLLEFSON

Siphoning carbon dioxide from the atmosphere could be more than an expensive last-ditch strategy for averting climate catastrophe. A detailed economic analysis published last week suggests that the geoengineering technology is inching closer to commercial viability.

The study was conducted by researchers at Carbon Engineering in Calgary, Canada, which has been operating a pilot CO_2-extraction plant in British Columbia since 2015. That plant — based on a concept called direct air capture — provided the basis for the economic analysis, which includes cost estimates from commercial vendors of all of the major components (D. W. Keith *et al. Joule* http://doi.org/cqqj; 2018). Depending on a variety of design options and economic assumptions, the cost of pulling 1 tonne of CO_2 from the atmosphere ranges from US\$94 to \$232. By contrast, the previous comprehensive analysis of the technology, conducted by the American Physical Society in 2011, estimated that it would cost \$600 per tonne (see go.nature.com/2xuauq7).

Carbon Engineering, which was founded in 2009, says that it published the paper to advance discussions about the approach's cost and potential. "We're really trying to commercialize direct air capture in a serious way," says David Keith, the company's acting chief scientist and a climate physicist at Harvard University in Cambridge, Massachusetts.

"It's great to see human ingenuity marshalling around a problem that at first pass seemed to be intractable," says Stephen Pacala, co-director of the carbon-mitigation initiative at Princeton University in New Jersey. He gives the Carbon Engineering team credit for publishing its results and subjecting its proprietary technology to public scrutiny.

The company's design blows air through towers that contain a solution of potassium hydroxide, which reacts with CO_2 to form potassium carbonate. The result, after further processing, is a calcium carbonate pellet that can be heated to release the CO_2. That CO_2 could then be pressurized, put into a pipeline and disposed of underground, but the company is planning instead to use it to make synthetic, low-carbon fuels. Keith says that Carbon Engineering can produce these for a cost of about \$1 per litre. When the company configured the air-capture plant for this purpose, it was able to bring costs down to as low as \$94 per tonne of CO_2.

Klaus Lackner, a pioneer in the field who heads Arizona State University's Center for Negative Emissions in Tempe, says that Carbon Engineering has taken a "brute-force" approach to driving down costs using known technologies. "They are coming within striking distance of making this interesting economically," he says. ■

MICROBIOLOGY

Faecal transplants could help preserve vulnerable species

New gut bacteria can expand the diets of animals such as koalas and rhinoceroses.

BY SARA REARDON

Koalas are among the world's fussiest eaters, consuming only the leaves of eucalyptus trees — and just a few varieties of eucalyptus at that. Research now suggests that the animals' discriminating diet is determined in part by the bacteria that live in their guts, which seem to restrict an individual koala's ability to digest certain species of eucalyptus.

The finding, which was presented on 8 June at the annual meeting of the American Society for Microbiology (ASM) in Atlanta, Georgia, comes amid a growing interest in how an animal's microbiome influences its ability to adapt to environmental change. Scientists studying koalas and other vulnerable species are trying to find out whether altering an animal's gut bacteria through its diet — or even faecal transplants — can increase survival.

That is an urgent question for the koala (*Phascolarctos cinereus*), whose habitat in Australia is under threat from human activity. In some places, the koala population dwarfs the supply of eucalyptus — but even when the animals are transplanted to areas with abundant food, some die. Experiments by koala ecologist Ben Moore and his colleagues at Western Sydney University in Australia suggest that this might be due to an incompatibility between available eucalyptus varieties and the mix of an individual koala's gut bacteria.

Moore and his colleagues collected faeces from 200 koalas at 20 sites around Australia. When the researchers analysed the plant materials in the faeces, they found that some koalas ate only a highly nutritious eucalyptus species known as manna gum (*Eucalyptus viminalis*). Others ate less-nutritious messmate (*E. obliqua*), and only a fraction of the animals would eat both — even at the same site.

When Moore and his colleagues analysed the microbial make-up of the faeces, they found that the koalas that preferred manna-gum eucalyptus harboured different bacteria from those that ate messmate. In an attempt to test whether the different diets were the cause or the result of the different microbiomes, the researchers transplanted faeces from six wild koalas that ate messmate into six wild koalas that preferred manna gum. Within 18 days, the microbiomes of the koalas that underwent the procedure were nearly identical to those of the donor animals. A few of the animals that received transplants also seemed more willing to eat messmate.

To Moore, this suggests that koala-to-koala faecal transplants might help to expand the types of food available to individual animals, and increase their chances of survival. Eria Rebollar, a microbial ecologist at the National Autonomous University of Mexico in Mexico City, says that the koala study is one of the first demonstrations that fecal transplants can modify wild animals' microbiomes.

Other experiments suggest that some animals could benefit from having their microbiomes reshaped by faecal transplants ▶

Koalas can be very picky about what kind of eucalyptus they eat.

▸ from another species. A team led by Denise Dearing, a molecular biologist at the University of Utah in Salt Lake City, found last year that desert woodrats (*Neotoma lepida*) — distant relatives of laboratory rats — carry gut bacteria that allow them to eat plants containing oxalate, a chemical that causes kidney stones. When the scientists, who work with Moore's group, transplanted woodrat faeces into lab rats, the lab rats gained the ability to degrade oxalate.

In some cases, helping endangered species survive might require changing their diets to accommodate their existing microbiomes. At the ASM meeting, scientists from the San Diego Zoo in California presented findings that suggest how the gut microbiome of the near-threatened southern white rhinoceros (*Ceratotherium simum simum*) could interfere with its fertility. Captive-born southern white rhinos do not reproduce well.

The team from the San Diego Zoo compared the faeces of captive white rhinos with those of one-horned rhinos (*Rhinoceros unicornis*), which reproduce well in captivity. The white-rhino faeces contained chemicals known as phytoestrogens, which are present in some plants and affect female reproductive hormones. Because both species of rhino ate the same diet, the researchers suspected that their gut microbes might break phytoestrogens down differently.

To test this, the zoo workers switched the female white rhinos' diet to grass pellets, which are low in phytoestrogens. Within two years, two females that had never successfully reproduced became pregnant; they later gave birth to healthy calves. Candace Williams, a molecular biologist at the San Diego Zoo, says that the facility is now feeding grass pellets to all its rhinos. She and her colleagues are trying to identify which bacteria might be responsible for the shift.

Dearing predicts that science will soon reveal many more instances of animals' microbiomes affecting their ability to survive. "I think it's more common than we've been able to document," she says. "We just didn't have the tools to do this until recently." ■