
PETE BUCKTROUT/BRITISH ANTARCTIC SURVEY

**The RRS *James Clark Ross* is one of Britain's two ageing polar ships, which are being replaced.**

OCEAN SCIENCE

# Fleet of polar ships raises science stakes

*RRS* Sir David Attenborough — *named Boaty McBoatface by the Internet — is part of a wave of hardy ice-going vessels.*

**BY ALEXANDRA WITZE**

The United Kingdom's new polar research vessel has become a national obsession. A proposal to christen the ship Boaty McBoatface captured the public imagination — so much so that the decision to name the ship instead after broadcaster and naturalist David Attenborough triggered questions in a parliamentary inquiry.

But the RRS *Sir David Attenborough*, which will probe both the Arctic and Antarctic, is also notable because it will carry more scientists and push deeper into polar ice than any UK research vessel ever has. It joins a wave of ice-strengthened research vessels — from Norway to China to Australia — that promise to expand scientists' ability to explore harsh polar environments (see 'Ships of the future').

China is soliciting bids to build a large research icebreaker to accompany its existing ship *Xuelong*, and the Australian government signed a contract last month for a replacement for its ageing *Aurora Australis*. Germany has started the process of replacing its vessel *Polarstern*, and Sweden is beginning to discuss what to do after its ship *Oden* is retired towards the end of the next decade. (A proposed pan-European icebreaker, costing up to €800 million (US$900 million), is on hold owing to its enormous price tag.)

The 129-metre-long *Attenborough* is designed by the team behind the *Kronprins Haakon*, an icebreaker being built for the Norwegian Polar Institute in Tromsø. When *Kronprins Haakon* sets off on its first science cruise in 2018, it will give Norwegian researchers a serious upgrade in their access to Arctic seas. It will replace a smaller vessel that can carry fewer scientists and operate only in light ice. "It's a whole new world for us," says project manager Øystein Mikelborg of the Norwegian Polar Institute.

## OVER ICE

Within weeks, architects will finalize the *Attenborough*'s design and workers in Merseyside, UK, will begin cutting steel for its hull, on track for a 2019 delivery.

Designers are cramming as many research goodies as possible into the £200-million (US$290-million) ship. The *Attenborough* will have a helicopter deck and, unlike Britain's existing polar-research vessels, a hangar. This will allow scientists to fly to otherwise inaccessible lakes or islands in Antarctica. And the *Attenborough* will have a hole in the hull known as a moon pool, allowing researchers to deploy oceanographic and geological equipment more smoothly and safely than by swinging it off the side of the ship.

Laboratory spaces will be kept at different temperatures, allowing storage and experiments of different types. The deck will have extra room for custom-made equipment for different cruises. Modern fibre-optic cables will deliver a live camera feed from as deep as 6,000 metres, from a remotely operated vehicle that will be called Boaty McBoatface, in a concession to the public vote.

Yet this increased research capability comes at a price: fewer days of actual science.

The British Antarctic Survey (BAS) currently operates two polar vessels, the 25-year-old RRS *James Clark Ross* for science, and the 21-year-old RRS *Ernest Shackleton*, which delivers equipment, food and people to its bases. To cut annual operating costs by 20%, the bigger *Attenborough* will replace both ships.

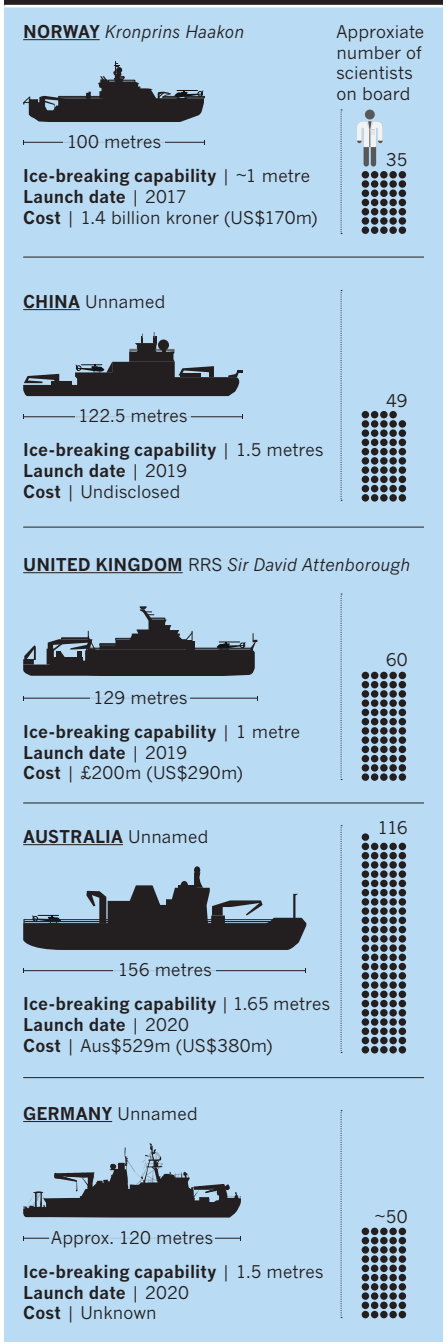
Instead of 180 days of science a year, UK scientists will get 150. The rest of the time (and space on the ship) will go to ferrying cargo. "I don't like to use the word compromise, but there is a trade-off," says Andrew Jeffries, project manager for the new boat and a BAS engineer in Cambridge, UK.

There have been other trade-offs between research and logistics. Ship designers have had to place the vessel's enormous diesel generators on isolating platforms to make the ship run silently, to avoid disturbing seismic and biological acoustics studies. The current design may also have to be tweaked to avoid vents from the helicopter fuel storage opening directly into areas where atmospheric scientists were counting on having clean air for their measurements.

Even with these trade-offs, researchers are eager for the *Attenborough* to launch. Not only

## SHIPS OF THE FUTURE

As climate change alters the polar seas, nations are upgrading their ability to conduct research in these ice-strewn waters.




will it be able to push through thicker ice and carry more scientists, but the ship will also be able to explore deeper environments than any other UK research vessel, says Katrin Linse, a deep-sea biologist at the BAS. That ability will allow it to carry out the first direct sampling of the 8.5-kilometre-deep South Sandwich Trench in the southern Atlantic Ocean. "We might find a new ecosystem there that we are not aware of yet," she says. "It's pretty exciting to get a new vessel. That only happens once every 30–40 years." ■

SYNTHETIC BIOLOGY

# Enzyme boost for mirror-image life

*Polymerase that can copy left-handed DNA marks step forward for looking-glass biochemistry.*

BY MARK PEPLOW

It's biochemistry — but not as we know it. Researchers at Tsinghua University in Beijing have created a mirror-image version of a protein that performs two of the most fundamental processes of life: copying DNA and transcribing it into RNA.

The work is a "small step" along the way to making mirror-image life forms, says molecular biologist Jack Szostak of Harvard Medical School in Boston, Massachusetts. "It's a terrific milestone," adds his Harvard colleague George Church, who hopes one day to create an entire mirror-image cell.

Many organic molecules are 'chiral': they can exist in mirror-image forms that cannot be superimposed, like a right-handed and left-handed glove. But life almost always employs one version: cells use left-handed amino acids, and have DNA that twists like a right-handed screw, for instance. In principle, looking-glass versions of these molecules should work together in the same way as normal ones — but they might be resistant to attack by viruses or enzymes that have not evolved in a looking-glass world.

That makes mirror-image biochemistry a potentially lucrative business. One company that hopes so is Noxxon Pharma in Berlin. It uses laborious chemical synthesis to make mirror-image forms of short strands of DNA or RNA called aptamers, which bind to therapeutic targets such as proteins in the body to block their activity. The firm has several mirror-aptamer candidates in human trials for diseases including cancer; the idea is that their efficacy might be improved because they aren't degraded by the body's enzymes. A process to replicate mirror-image DNA could offer a much easier route to making the aptamers, says Sven Klussmann, Noxxon Pharma's chief scientific officer.

### THROUGH THE LOOKING-GLASS

Researchers have been making chunks of mirror-DNA for decades, so the Tsinghua team could order much of what it needed for its looking-glass DNA replication attempt from a chemical supplier — a mirror-DNA strand to be copied, mirror-DNA building blocks and a shorter mirror 'primer' strand that could pick up these building blocks in the right order.

The difficult task was to make the mirror-image enzyme that coordinates the copying process, called DNA polymerase. That would need to be synthesized from right-handed amino acids, but commonly used polymerase enzymes have more than 600 amino acids — meaning that they are too big for current synthetic methods.

So the Tsinghua team turned to the smallest known polymerase: African swine fever virus polymerase X, which contains just 174 amino acids. Unfortunately, it is also spectacularly slow — probably because of its small size, says synthetic biologist Ting Zhu, a former graduate student of Szostak's who helped to lead the work. The team made a mirror version of the enzyme and found that, like its natural equivalent, it could extend a mirror-primer consisting of 12 nucleotides (DNA building blocks) to an 18-nucleotide mirror-DNA strand in about 4 hours; and to a 56-nucleotide strand in 36 hours.

When the normal and mirror-image versions of these systems were mixed together in the same test tube, both replication processes worked independently without interference. The mirror-image polymerase could also transcribe mirror-DNA into mirror-RNA — a relatively rare feat for a polymerase — again at a glacial pace. The work is published in *Nature Chemistry* (Z. Wang *et al. Nature Chem.* http://dx.doi.org/10.1038/nchem.2517; 2016).

***"For a while mirror-image biochemistry was a non-field. But now it seems very vibrant."***

Klussmann says that Noxxon Pharma is interested in pursuing a similar approach with a more efficient enzyme. Indeed, Zhu and his colleagues next hope to build a mirror-image of a more efficient polymerase known as Dpo4, which is built of 352 amino acids.

In their research paper, the Tsinghua researchers also present their work as an effort to investigate why life's chirality is the way it is. This remains mysterious: it may ▶