How bacteria break a magnet

A magnetosensing bacterium bends its internal magnet to weaken it before cell division.

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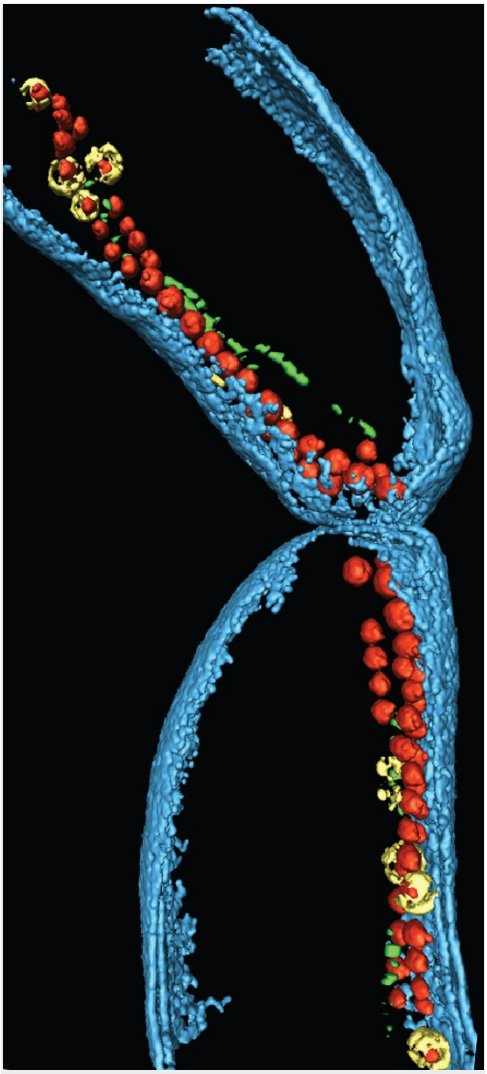
Bacteria that contain an internal compass face an unusual challenge when they come to divide: snapping their internal magnets in two. A report[1] in the December issue of *Molecular Microbiology* explains how one species generates the force to separate magnetic nanoparticles and apportions them equally between daughter cells.

Richard Blakemore first described magnetotactic bacteria — which can orient themselves in line with Earth's magnetic field — in the 1970s[2]. The magnets probably help oxygen-averse marine bacteria to navigate waters and sediments where the levels of chemicals such as oxygen and sulphide change quickly with depth, says Dirk Schüler, a microbiologist at the Ludwig–Maximilians University in Munich, Germany, who led the study[1].

Bacteria build their compasses from tiny organelles called magnetosomes, which contain crystals of magnetite (Fe_3O_4) and and/or greigete (Fe_3S_4) other magnetic minerals. No single magnetosome produces a magnetic field strong enough to align a bacterium to Earth's magnetic field, so the organelles gather together in a chain to form a stronger magnet.



Katzmann E. et al. 2011, Mol. Microbiol.

Magnetotactic bacteria bend their chains of magnetosomes (red) before cell division.

When cells divide, however, they must create enough force to sever their magnets. Bacteria normally divide by first growing lengthwise and then constricting their cell walls at the centre, as if tightening a belt, until the walls meet and two cells are formed. But, says Schüler, belt-tightening doesn't generate nearly enough force to tear apart a magnetosome chain.

Magnetochoreography

Using both light and electron microscopy, Schüler's team tracked the bacterium *Magnetospirillum gryphiswaldense* as it split into two. Initially, the process followed the normal choreography of bacterial division: the cell lengthened and then slowly constricted at its centre. Next, however, the two soon-to-be daughter cells bent at up to a roughly 50-degree angle to one another, then rapidly broke off into two cells. The moustache-like bend was created because the cells were pinched into two on only one side, Schüler says.

Schüler's team calculates that bending the magnetosome chain in this way would weaken the magnetic forces holding it together to the point at which it could be snapped in two. "If you break them like a stick, you're talking about 10 piconewtons," Schüler says — equivalent to the force normally produced during cell division.

The group's experiments also explain how *M. gryphiswaldense* divides up its magnetosomes equally between the two cells. Schüler predicted that this would occur by chance alone, because each bacterium contains several dozen magnetosomes. But the researchers discovered that cytoskeletal proteins yank the magnetosome chain towards the centre when cell division begins, ensuring that the magnets are shared equally.

"The work is, in my opinion, top-notch," says Dennis Bazylinski, a microbiologist at the University of Nevada, Las Vegas. He agrees that asymmetric cell division explains how *M. gryphiswaldense* snaps its magnet in two. However, other magnetotactic bacteria, a diverse group with many different shapes, may have come up with different solutions.

Bazylinski's team is studying an organism tentatively named *Magnetovibrio blakemorii* (after Richard Blakemore) that keeps its magnetosomes spaced far apart, an arrangement that could make the chain easier to split.

Meanwhile, some magnetotactic bacteria produce multiple intertwined chains of magnetosomes, others dot the organelles within the cell membrane, and one strain maintains two chains, one at each end of the cell, says Arash Komeili, a microbiologist at the University of California, Berkeley. "My gut feeling is that some aspects of this process are unique to *M. gryphiswaldense* and not generalizable to all magnetotactic bacteria," he says of Schüler's work.

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References

1. Katzmann, E. *et al*. *Mol. Microbiol.* **82**, 1316–1329 (2011).
2. Blakemore, R. *Science* **190**, 377–379 (1975)