We've discovered microbes growing pretty much everywhere: in extremely hot, acidic, cold, salty, or arsenic-loaded environments. We've found them thriving at the bottom of the ocean, inside rocks miles below the Earth's surface, and in outer space (after we put them there, of course).

But now, scientists publishing in the Proceedings of the National Academy of Sciences this past May have found that bacteria can also survive under a different kind of stress: hypergravity.

The researchers tried growing several different microbial species, including *Escherichia coli*, *Paracoccus denitrificans*, and the yeast *Saccharomyces cerevisiae*. Unfortunately, they did not travel to one of our solar system's giant planets to test the effects of hypergravity, but rather simulated it by spinning the microbes in a centrifuge fast enough that they experienced forces greater than 403,000 times Earth's gravity. They incubated the cells spinning in the centrifuge for up to 5 days, and then took them out and plated them on medium to see how many were still alive.

P. denitrificans was able to grow at the highest gravity, though its growth rate was slowed down a little. *E. coli* could only grow well at forces up to 134,000 times Earth gravity—"only"—but after a while it did grow a little at 403,000.

A Gram-positive organism they tested, a *Lactobacillus*, was more sensitive: growth was slightly reduced even at 100 times gravity, and significantly lower at 22,500.

The yeast, *Saccharomyces*, was also sensitive, being very affected at almost 45,000, and not growing at all at 74,500.

Growing in an ultracentrifuge presents a number of challenges for cells to overcome. For example, they're stuck at the bottom of the centrifuge tube in a pellet that gets denser as gravity increases, so there's not as much room for nutrients to get in to the cells in the center. Their internal components, such as ribosomes and other large enzymes, may fall to one side of their inner space also, slowing down some processes. This effect would be larger for larger cells, such as the yeast, which also have even larger structures called organelles that would be more greatly affected.

While larger creatures like us can be deformed by only a few times Earth's gravity, microbes are not very affected due to their small size. The same is true about pressure from the liquid in the centrifuge tube surrounding the cells. The liquid is affected by gravity too, and presses down harder and harder on the cells, but they can hold up well, as we know from finding bacteria growing at the bottom of the ocean and such.

While this research was done on Earth, it may have more implications for life on other planets. Celestial bodies called brown dwarfs are larger than Jupiter though smaller than stars such as the Sun, and have gravity forces between 10 and 100 times that of Earth, but now we know that such forces wouldn't necessarily affect microbes, so we might expect to find tiny life in such places.

This work also has implications for the viability of the idea of panspermia, that life on Earth might have gotten started when life from another planet traveled here on chunks of rock ejected by meteorite strikes. These chunks of rock would have been ejected from a planet such as Mars at forces up to 300,000 times Earth's gravity, which apparently might not disturb any bacteria—or rather, alien microbes—lurking on those rocks.

For a more terrestrial application, hypergravity may affect microbial metabolism, so it might be useful for some biotechnological applications, such as fermentation or pharmaceutical production.

Something to note, though: while 403,000 times gravity seems like an excessive amount, it is quite possible that the bacteria could still have grown under higher numbers; the researchers stopped where they did only because that was the highest force their equipment could produce. I wonder if there might be bacteria living in black holes?