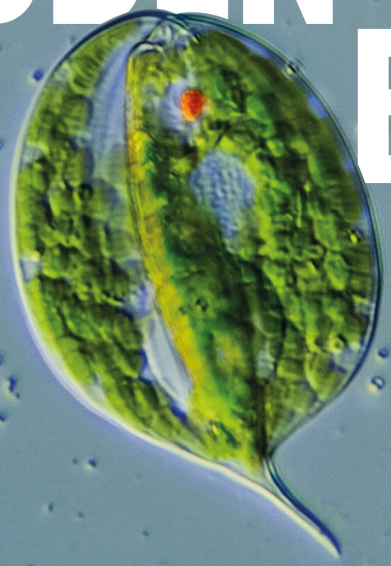
What the tiniest forms of life can tell us about existence and our place in the universe

The HIDDEN BEAUTY

of the Microscopic World



JAMES WEISS

From the content creator of the hit YouTube show
Journey to the Microcosmos

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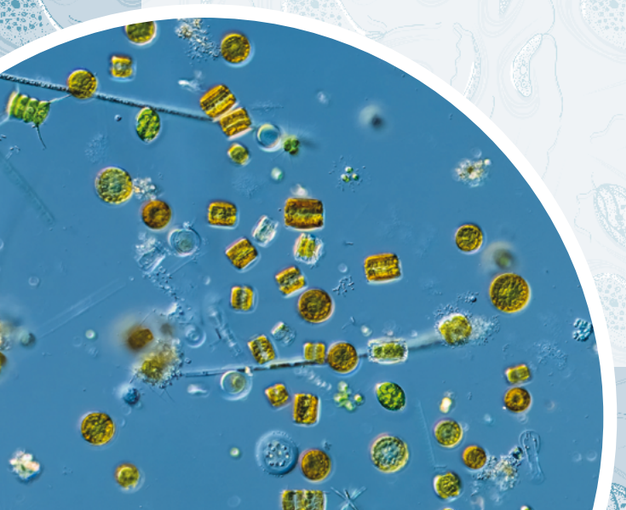
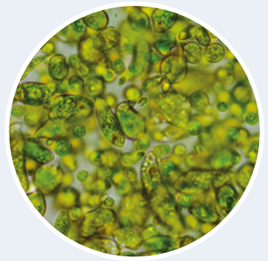


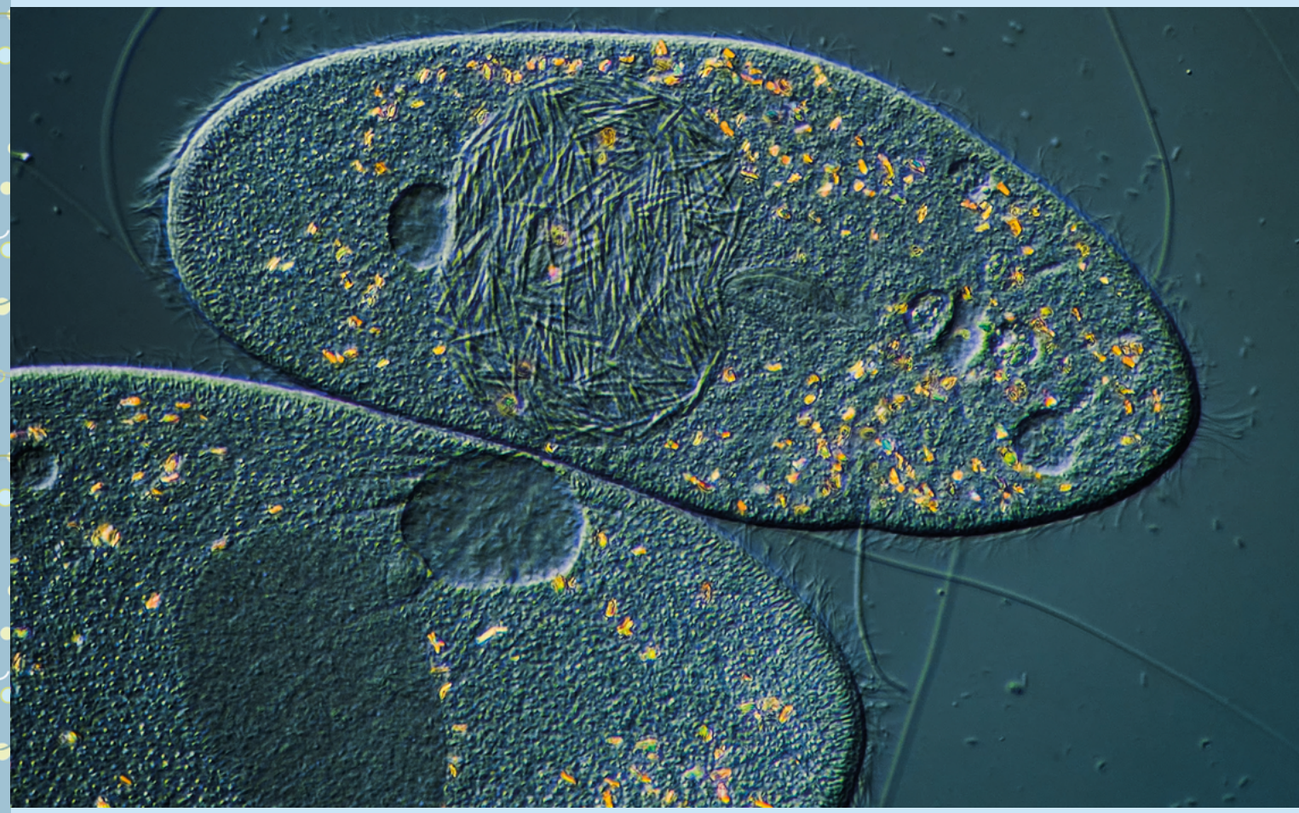


OPPOSITE: Diatoms. **ABOVE (FROM LEFT TO RIGHT):** *Daphnid*, euglenids, *Chroococcus*.

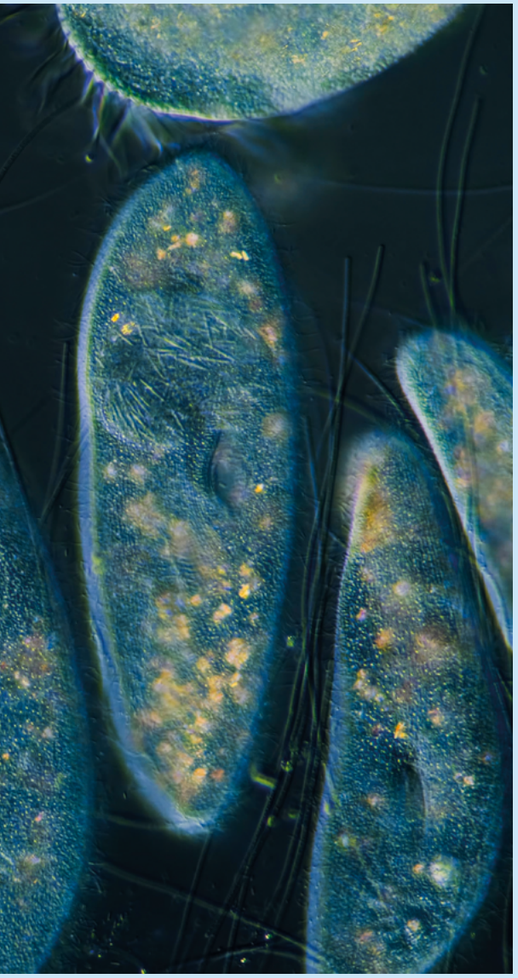
Bacterial parasites of *Paramecium* – **life within life**

Bacterial infections are not limited to multicellular organisms like you and me. Bacteria can infect, harm and even kill some single-celled organisms. There are peculiar interactions between bacteria and single-celled eukaryotes; for instance, the *Paramecium* species may be a host for about 60 species of bacteria. These are called bacterial endocytobionts and they don't necessarily harm the host. However, some of these endocytobionts can be parasitic too. After I got my first microscope and started to dive into the microcosmos, I read a paper about some parasitic bacteria in *Paramecium*. It was mind-blowingly interesting, but I never thought I would see some infected *Paramecium* with my own eyes.

Paramecia are one of the most common organisms I find, and after years of seeing them on my slides, they kind of became a little uninteresting. And, honestly, they even became a bit annoying! Imagine you're finding a perfect composition for a photo or a video and then an overly excited *Paramecium* comes along and destroys your precious photo. They were the smallest photobombers I have ever had to deal with. I was even often separating them with a micropipette from the drop of water under a low magnification before covering the drop with a coverslip. Although one time, three years into using my microscope,



ABOVE: *Paramecium* with an infected nucleus (above), *Paramecium* with a healthy nucleus (below), 180 microns.



OPPOSITE:
Paramecia,
160 microns.

I spotted some strange structures inside a *Paramecium* that was zooming around on my slide. I couldn't believe my eyes: these were the parasitic bacteria I read about years ago!

The bacteria I was seeing belonged to a genus called *Holospora* and they were infecting the nuclei of the *Paramecium*. These bacteria were first reported in 1890 by the bacteriologist Sir Waldemar Mordechai Wolff Haffkine in a laboratory aquarium in France. The origin of the infected *Paramecia* were never found, and they haven't been reported in France since 1890. I couldn't find much information about the aquarium where Haffkine first reported the *Holospora*, but I bet it was an aquarium where they dumped old samples to have something to show to students later. I have a similar one at home where I put my old samples rather than flushing them down the drain.

Paramecium is part of a diverse group of microorganisms called ciliates, which we will cover extensively in part two. However, it's important to note that *Paramecia* and other ciliates have two types of nuclei: one is called the macronucleus, which basically maintains the metabolism of the cell, and the other is called the micronucleus, which holds the germline genetic material for the next generation of *Paramecia*. Haffkine found three different species of the bacteria that were infecting *Paramecia* in the aquarium. He named them *Holospora obtusa*, which targeted the macronucleus, and *H. undulata* and *H. elegans*, which were parasites of *Paramecium*'s micronucleus. Since Haffkine's work, seven other *Holospora* species have been described.

Holospora species target specific nuclei of a specific *Paramecium* species. For instance, *Holospora obtusa* only infects *Paramecium caudatum*'s macronucleus, while *Holospora undulata* only infects the micronucleus of *Paramecium caudatum*. *Holospora* cannot grow outside the cell, and they show two different forms during their life cycle: a reproductive form and an infectious form. The bacteria find their way into the cell when the *Paramecium* is eating. When the infectious form of *Holospora* is taken into the *Paramecium*, it's wrapped in a membrane with a bunch of other food particles and bacteria, but the *Holospora* does something that other bacteria inside the food vacuole cannot. It saves itself from being digested, leaves the food vacuole and uses *Paramecium*'s own cell network to travel in cytoplasm and find its way to the nucleus it targets. Once it has penetrated the nucleus and started the formation of reproductive forms, it divides inside the nucleus. When the host lives in favourable conditions, these reproductive forms of *Holospora* stay in this stage, but when the *Paramecium* starves, the bacteria change into their infectious form. This allows them to return into the environment and infect more cells in two different ways.

The first way occurs during the cell division of the *Paramecium*: the infectious forms are "collected" between connecting pieces of the dividing nucleus and wrapped with the nuclear membrane. Later, the *Paramecium* expels these infectious forms through the cell anus (yep,

OPPOSITE: *Paramecium* with infected micronucleus, 180 microns.

that's a thing) into the environment. The second way for infectious forms to leave the cell is actually how I found them in my sample: The infectious forms fill the whole nucleus, and once the nucleus is overrun by the bacteria, the *Paramecium* cannot grow or maintain the cell and dies, scattering the bacteria back into the environment.

I collected some of the *Paramecia* from my sample and cultured them in a jar. My culture looks quite "healthy", so I add a drop of milk into the culture from time to time to create some food for the *Paramecia*. I believe there are two species of *Holospora* infecting my *Paramecia*. Out of every 100 cells of *Paramecia,* I see 3 or 4 individuals with their macronucleus full of *Holospora*. After over a month of observations, I've seen four cells with infected micronucleus so far. It's absolutely fascinating to find something so remarkable, and I'm hoping to keep the bacteria alive in my culture for further investigation. I'm not expecting a groundbreaking discovery, but they will surely keep me busy for some time! I hope to keep the bacteria alive until I am able to upgrade my microscope with a flourescent light so I can stain the bacteria with some specific dyes that shine under the flourescent light and give me more details about the bacteria. Specifically, I want to observe the bacterium using *Paramecium*'s own cell structures to locate and migrate to the specific nuclei it targets!