KYUSHU UNIVERSITY

Public Relations Office, Kyushu University
744 Motooka Nishi-ku Fukuoka, 819-0395
TEL: +81-92-802-2443 FAX: +81-92-802-2139
E-MAIL: koho@jimu.kyushu-u.ac.jp
URL: https://www.kyushu-u.ac.jp

PRESS RELEASE (2025/04/10)

Simulating the fluid dynamics of moving cells to map its location
Researchers simulate the fluid dynamics of flowing biological cells and propose a new technique for cell separation, drug screening, and developing artificial hearts

Fukuoka, Japan—As you read this sentence, trillions of cells are moving around in your body. From the red blood cells being pumped by your heart, to the immune cells racing across your lymphatic system, everything you need to live pulsates and flows in a turbulent dance of finely tuned biological machinery.

Because its physical properties are so unique, understanding the fluid dynamics of flowing biological cells like these has been an important topic of research. New insights can lead to the development of better microfluidic devices that study disease, and even improve the function of artificial hearts. However, live tracking and observing flowing cells as it moves across the body is still a challenge.

Now, utilizing numerical simulations, researchers from Japan have succeeded in recreating the fluid dynamics of flowing cells. In their paper, published in the *Journal of Fluid Mechanics*, the team created an *in-silico* cell model—a simulation of biological cells—by programing them as deformable 'capsules,' and placed them in a simulated tube under a pulsating 'flow,' mimicking how cells travel through a vessel. They found that these capsules will move to a specific position in the tube depending on two factors: the deformation of the capsule and the pulsation frequency. Essentially, the system provides researchers the tool to identify 'where' and 'how' cells move through a vessel.

The fluid dynamics of a moving cell is quite unique. They will get pushed around through the body in regular intervals, and passes through tubes that can vary in size and composition under different flow conditions. Cells are also very flexible and will stretch and deform as it works through your body, something that also effects its fluid dynamics.

"To better understand cell behavior under unsteady flow we constructed a numerical model that simulates the physics of cells in tubes under pulsating flows," explains Associate Professor Naoki Takeishi from Kyushu University's Faculty of Engineering, who led the study.

"This would allow us to figure out how cells statistically distribute in a system," continues Takeishi. "In our experiment we simulated cells as deformable capsules. Because we were simulating capsule dynamics in a wide range of conditions, we required heavy computational resources."

In their simulations, the team revealed that there exists a pulsation frequency at which the capsule stretches and shrinks, allowing it to move stably away from the tube's center—where the flow is the fastest—toward areas with slower flow. Interestingly, even if the flow speed is increased the pulse frequency remains the same. On the other hand, under slow flow conditions, capsules would tend to converge quickly to the center of the tube.

"Our results show that the behavior of flexible particles, like biological cells, in a flowing tube depends not only on the amount of deformation—that has already been known—but also on the pulsating frequency," continues Takeishi. "Moreover, we can control the capsule position by adjusting that frequency."

The team hopes their new findings can be utilized in research that require precise cell and fluid manipulation such as in cell alignment, sorting, and separation. These techniques are particularly relevant for isolating moving tumor cells in cancer patients.

"At present, there is no biological consensus on whether steady or unsteady blood flow is preferable in artificial hearts," concludes Takeishi. "Our numerical results form a fundamental basis for further study, not only on the essential movement of cells in the body, but also in the development of artificial organs, particularly the heart and blood vessels."

###

For more information about this research, see "Inertial focusing of spherical capsule in pulsatile channel flows," Naoki Takeishi, Kenta Ishimoto, Naoto Yokoyama, Marco Edoardo Rosti, *Journal of Fluid Mechanics*, https://doi.org/10.1017/jfm.2025.184

About Kyushu University
Founded in 1911, Kyushu University is one of Japan's leading research-oriented institutes of higher education, consistently ranking as one of the top ten Japanese universities in the Times Higher Education World University Rankings and the QS World Rankings. The university is one of the seven national universities in Japan, located in Fukuoka, on the island of Kyushu—the most southwestern of Japan's four main islands with a population and land size slightly larger than Belgium. Kyushu U's multiple campuses—home to around 19,000 students and 8000 faculty and staff—are located around Fukuoka City, a coastal metropolis that is frequently ranked among the world's most livable cities and historically known as Japan's gateway to Asia. Through its VISION 2030, Kyushu U will "drive social change with integrative knowledge." By fusing the spectrum of knowledge, from the humanities and arts to engineering and medical sciences, Kyushu U will strengthen its research in the key areas of decarbonization, medicine and health, and environment and food, to tackle society's most pressing issues.

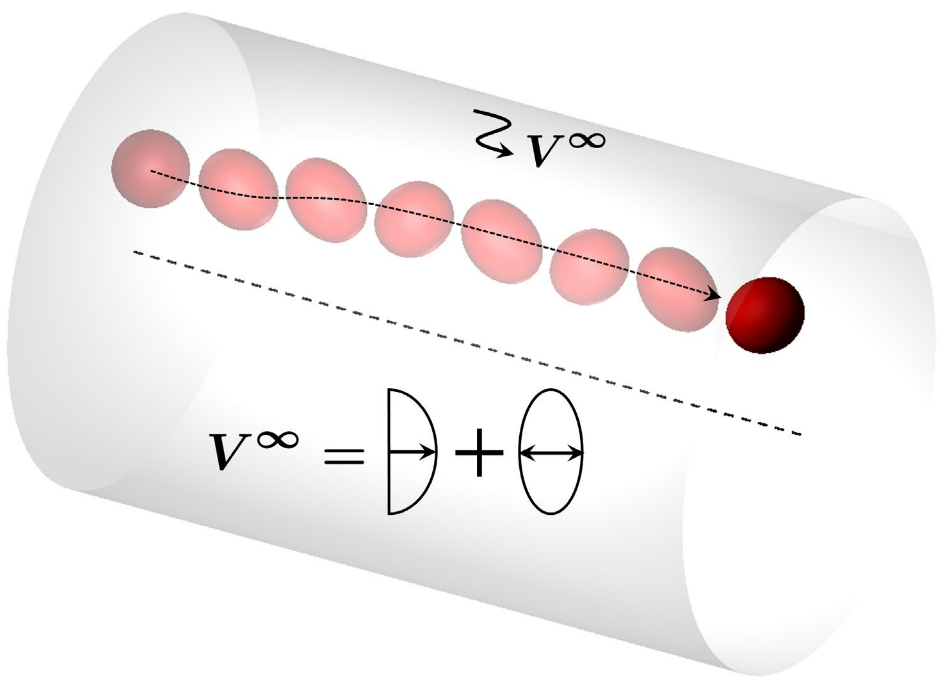

Fig. 1. Capsule in a flow. Behavior of a spherical capsule in a pulsatile flow. A single capsule moving in the direction of the flow is superimposed. (Takeishi Lab /Kyushu University)

[Contact]
Naoki Takeishi, Associate Professor
Faculty of Engineering Department of Mechanical Engineering
Tel: +81 92 802 3070
E-mail: takeishi.naoki.008@m.kyushu-u.ac.jp