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PRESS RELEASE (2026/04/28)

# Understanding how oxygen is delivered to tissues at the microscopic level

## A new computational model reveals how red blood cells help maintain stable oxygen levels in the body

**Fukuoka, Japan**—Researchers at Kyushu University and Institute of Science Tokyo have developed a new computational model that can simulate the transport of oxygen by red blood cells (RBCs) through tiny blood vessels—or capillaries—and their delivery to surrounding tissues. Published in the *International Journal of Heat and Mass Transfer* on April 27, 2026, the study reveals that RBCs can naturally adjust the amount of oxygen released based on local requirements and help maintain a stable level of oxygen throughout the body.

Oxygen transport is one of the most essential processes for life. Every passing second, RBCs in the blood carry oxygen from the lungs through a network of microscopic channels and release it into tissues, where it is used to produce energy. The process consists of multiple overlapping steps, including blood flow, diffusion of oxygen, chemical reactions inside cells, and oxygen uptake by tissues. As these processes occur simultaneously and at the microscopic level, it has been difficult to understand the regulation of oxygen delivery in the body.

In this vein, Associate Professor Naoki Takeishi from Kyushu University's Faculty of Engineering along with collaborators from Institute of Science Tokyo, and Osaka University, developed a new mathematical model that combines these processes into a single framework.
"We applied equations that describe how oxygen moves, reacts, and is consumed, while also accounting for the motion and deformation of individual RBCs within blood flow," explains Takeishi.

Using this approach, the researchers were able to simulate oxygen transport across a complex network of capillaries in the body. They were also able to capture the movement of oxygen inside RBCs, the surrounding fluid, and into the tissues; all within a single system.

The findings revealed that even when RBCs are unevenly distributed in capillaries, they can regulate oxygen delivery in a way that maintains balanced oxygen levels in tissues. This occurs because oxygen release depends on local oxygen concentration: in low-oxygen regions, a greater amount of oxygen is released, while in areas with higher oxygen levels, the amount released is lower. This self-regulating behavior helps establish uniform tissue oxygenation.

The model also helped understand the variation in the flow behavior of blood, which also varied under similar conditions. Variations like movement of RBCs and deformation within branching capillary networks can influence flow resistance, indicating that blood flow properties are not always predictable from simple assumptions.

"Our model allows us to examine how multiple physical and chemical processes work together during oxygen transport," says Takeishi. "It provides a way to connect the behavior of

individual RBCs with oxygen delivery at the tissue level."

The applications of this developed model are vast and could be applied beyond oxygen transport processes. It could help researchers better understand how different organs function and support the design of artificial systems for delivering oxygen or drugs within the body. As the modeling approach can be extended to general mass transfer problems, it may also prove useful in engineering fields involving transport of complex materials.

Looking ahead, the researchers aim to validate their work with experimental observations and apply their model to other complex biological processes, such as the transport and removal of metabolic waste in the brain.

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For more information about this research, see "Diffuse interface approach to oxygen transport and metabolism under blood flow dynamics in microcirculations," Naoki Takeishi, Junya Kobayashi, Shigeo Wada, and Satoshi Ii, *International Journal of Heat and Mass Transfer*, https://doi.org/10.1016/j.ijheatmasstransfer.2026.128822

About Kyushu University
Founded in 1911, Kyushu University is one of Japan's leading research-oriented institutions 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. Located in Fukuoka, on the island of Kyushu—the most southwestern of Japan's four main islands—Kyushu U sits in a coastal metropolis frequently ranked among the world's most livable cities and historically known as Japan's gateway to Asia. Its multiple campuses are home to around 19,000 students and 8,000 faculty and staff. 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.

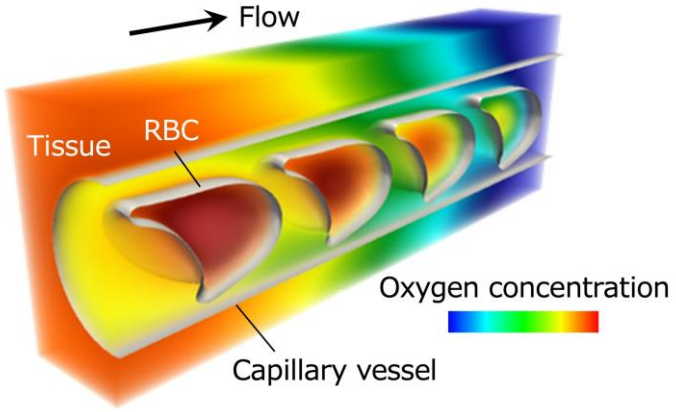


**FIG.1** Simulating how red blood cells carry and release oxygen in surrounding tissues
Schematic of how individual red blood cells (RBCs) carry oxygen through capillaries to oxygenate tissues. The team found that RBCs can regulate how much oxygen is released in tissues, wherein low-oxygen concentration regions, a greater amount of oxygen is released, while in areas with higher oxygen concentrations, the amount released is lower.

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