Flow velocity in the gut regulates nutrient absorption and bacterial growth

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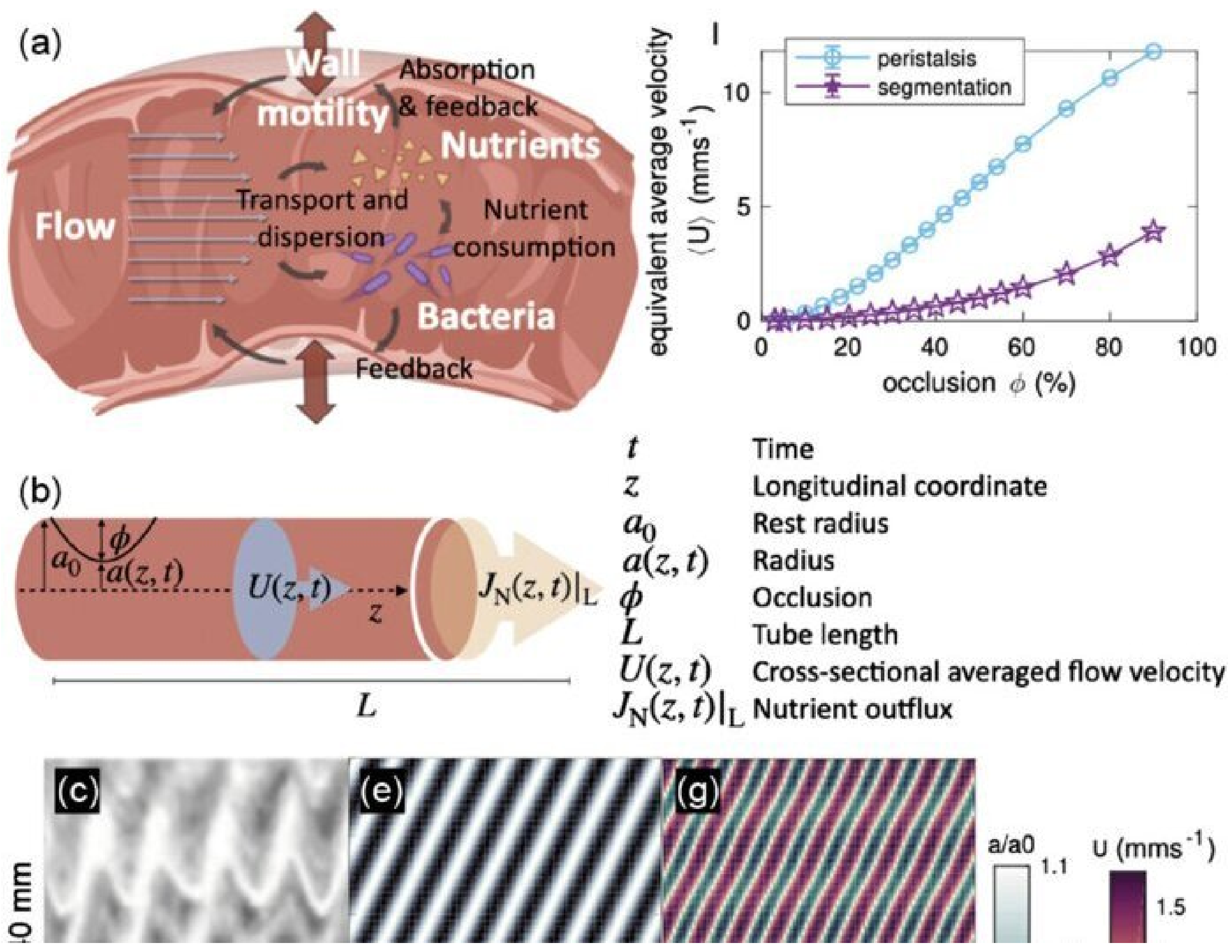

Gut motility determines flows. (a) The gut is a muscular tube, whose motility patterns induce flows that affect the abundance of nutrients and bacteria. Abundances, in turn, feed back on motility. (b) Mathematical notation. (c) and (d) In vitro spatiotemporal map of the contraction amplitude observed for the small intestine of mice, during peristalsis and segmentation, respectively. "Motor patterns of the small intestine explained by phase-amplitude coupling of two pacemaker activities: the critical importance of propagation velocity," used with permission. (e) and (f) Simulated contraction amplitudes $a(t,z)/a_0$ with 10% occlusion and (g) and (h) the emerging flow U for peristalsis and segmentation. (i) Equivalent average flow velocity $\langle U \rangle$ as function of occlusion ϕ for peristalsis (blue) and segmentation (purple). (a) Courtesy of Sara Gabrielli. Credit: *Physical Review Letters* (2022). DOI: 10.1103/PhysRevLett.129.138101

The flow velocity in our digestive system directly determines how well nutrients are absorbed by the intestine and how many bacteria live inside it. This is the result of a new study by researchers from the Technical University of Munich (TUM) and the Max Planck Institute for Dynamics and Self-Organization (MPI-DS). The researchers revealed the physics mechanisms of how the intestine can regulate itself to optimize nutrient absorption while limiting unwanted bacterial growth at the same time.

Curled in the abdomen, the human intestine is around 7 meters long. It takes around eight hours for food to pass the small intestine for digestion. During that time, nutrients from the food are absorbed by the enhanced surface of the gut. At the same time, beneficial bacteria located in the intestine contributing to digestion are also absorbing nutrients from the passing food.

Researchers from TUM and the MPI-DS now showed that nutrient absorption and bacterial levels are directly coupled to the flow velocity in the gut: at high flow rates, bacterial growth is contained, but at the same time nutrient absorption in the gut is also worsened. On the contrary, a low flow can improve nutrient absorption, but also favors excessive bacterial growth which may be harmful to the digestive system over time.

Complex dynamics revealed

The researchers for the first time revealed the complex dynamics between nutrient absorption, flow, and bacterial growth. "Our model based on mice showed that at a certain flow speed an optimal nutrient absorption is achieved, while optimal bacterial levels are obtained for a different flow speed," says Karen Alim, Professor of Theory of Biological Networks at TUM and Research group leader at MPI-DS.

"Our results suggest that the gut alters between these different flow speeds to regulate nutrient absorption and bacterial levels, in coordination with meal-intake or fasting, and on the bacterial level reached in the intestine," explains Agnese Codutti, first author of the study. This way, the nutrient absorption, as well as the bacteria levels, also influence and give feedback on gut flow regulation.

Our health depends on our gut behavior

But what happens when the gut is not working properly? Any disruption in the gut flows and in the feedback mechanisms may lead to excessive bacterial growth. This could have serious consequences on our health, provoking chronic fatigue, headaches, poor nutrient absorption, and bloating.

The new findings of the study, published in *Physical Review Letters*, provide important insights into mechanisms behind these diseases and can help to preserve a healthy gut.

More information: Agnese Codutti et al, Changing Flows Balance Nutrient Absorption and Bacterial Growth along the Gut, *Physical Review Letters* (2022). DOI: 10.1103/PhysRevLett.129.138101