Location, location, location: Cell sizes, lives influenced by host size

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Cells from the smallest to the largest of mammals often seem to be “one size fits all.” Now a closer look reveals that whether a cell lives in an elephant, mouse or something in between can make a big difference in its life.

Researchers from the University of Florida Genetics Institute, Harvard Medical School and other institutions developed mathematical models that they used to examine 18 cell types from mammals ranging from mice to elephants. They found two basic categories — cells that stay the same size but have drastically different energy needs that depend on the size of the mammal, or cells that grow larger in larger mammals and use energy at the same rate, no matter the mammal’s size.

The discovery, published online this month in the *Proceedings of the National Academy of Sciences*, begins to answer questions about how the size of an organism helps determine the life span of its cells, a finding that could help cell biologists and physiologists understand cell and organ function and their relation to disease.

“Although cells are basic building blocks, their metabolic rates depend on where they find themselves living,” said Van M. Savage, the lead author of the research and an instructor in the department of systems biology at Harvard Medical School. “Conceptually this is important because huge amounts of research on human diseases are done on single cells or cultured cells that come from other animals and little is done to place these findings within the context of the size or other whole-body properties of the animals."

Generally, the size of a species of mammal sets the pace of its life, Savage said. The life spans of a mouse and elephant can differ by more than 70 years, and it takes a mouse 20 days of gestation before delivering a baby compared with more than 600 days for an elephant. The larger the animal, the slower its cellular metabolic rate — the speed at which it burns oxygen — and life processes.

The question of whether cells are bigger in larger mammals than in smaller ones — think of an elephant's liver cell compared with a liver cell from a mouse — is usually answered by saying that larger mammals don't typically have bigger cells, they just have more of them.

Liver cells, red blood cells and other cell types that frequently divide and replace themselves are about the same size, but more permanent, long-lived cells, such as brain and fat cells, are indeed larger in large mammals.

"Fat cells increase in size tremendously if you move from a mouse to an elephant," said James Gillooly, an assistant professor in the zoology department of UF's College of Liberal Arts and Sciences. "Neurons also increase in size. But red blood cells are the same size whether they are in a mouse or an elephant. The reason brain and fat cells grow bigger could be because they live longer and have important long-term functions. In these cases, the properties of the cell are linked to the whole organism. But the sizes of quickly dividing cells are independent of the organism."

Neurons are essential parts of brain networks that retain memory, the researchers said, while fat cells are storehouses of energy that are vital for an animal's survival when food supplies are short. As such, they are too valuable and would require a great deal of energy to be continually used and replenished in the body.

Scientists from the Santa Fe Institute, the Los Alamos National Laboratory, the National Center for Ecological Analysis and Synthesis and the University of New Mexico also participated in the study.

"The authors are saying cell size, body size and life span all go together," said Samuel Wang, an associate professor of molecular biology and neuroscience at Princeton University who was not a member of the research team. "In the case of brains, this suggests a reason having little to do with information processing for why bigger brains have more complex neurons than small ones. Instead of saying neurons are larger because of demands for information processing, it suggests information processing might be constrained by the fact that neurons are larger. But it doesn't answer why different neurons get bigger to different extents, so there is still a lot of room to develop answers about why neurons scale up the way they do."

More study is needed to understand the interplay between an organism and its cells, scientists say.

"Despite the progress that has been made in cell biology, we still have a relatively poor understanding about general characteristics of cells across species," Savage said. "The focus has been on how cells affect the whole organism, not on how the size of the organism and its energy requirements affect the cells."

Source: University of Florida

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