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Rooms Within Rooms

Reading level 13 · 1313 words

In 1665 a man looked at a slice of cork and named what he saw cells. He was wrong about what they were. So was almost everyone after him, and getting it wrong turned out to be useful. The man was Robert Hooke, and his word, from the Latin for a small room, outlived his mistake. What he had seen were the empty walls of plant tissue. His weak microscope could not show whether anything had ever lived inside them. This essay follows how the picture of the cell was redrawn again and again, and what the textbook definition still leaves out.

The next advance came from a man with no scientific training. Antonie van Leeuwenhoek was a draper in Delft who grew curious about microscopes after seeing one, and he taught himself to make his own. Earlier lenses had magnified about 50 times. His tiny glass spheres reached about 270. With them he drew bacteria from his own mouth and protozoa from rain water. In October 1676 he wrote to the Royal Society that these creatures must be alive, because they moved. It was an argument from behavior. The man who made it thought of himself as a businessman, and he was at first reluctant to publish what he had found.

Cell theory is usually credited to two scientists. Around 1838 and 1839, Matthias Schleiden and Theodor Schwann showed that plants and animals are built of cells. They were wrong about where new cells come from, because Schleiden thought cells formed like crystals. In the 1850s Robert Remak, Rudolf Virchow and Albert Kolliker proved otherwise. In 1855 Virchow put the third claim in Latin: Omnis cellula e cellula, or every cell comes from a cell. Remak had published the idea first, and it has been suggested that Virchow took it from him. Arguments over who came first are as old as science. Whoever deserves the credit, the claim itself has held up: the cell is the basic unit of structure and function in living things.

Picture a swimming pool full of thick soup, floating in a clear lake, with only a thin skin between them. The skin has to stop the soup from thinning out, and that is a fair picture of a cell's membrane. The proteins packed inside a cell far outnumber those outside, whether the outside is ocean water or blood. Keeping up that difference takes constant work, and the work costs energy. Cells may use as much as 30 percent of their energy just to keep the inside of their cytoplasm the way it needs to be. A cell is best thought of as a standing disagreement with its surroundings, held up by effort.

Cells come in two broad designs. The simple kind, found in bacteria and archaea, has no nucleus and no other walled-off rooms. Most bacteria are only 0.1 to 5 micrometers across. The complex kind, which has a nucleus, is often much larger and carries more genetic information. Exceptions blur the line. Thiomargarita magnifica, a bacterium about a centimeter long, can be seen without a microscope. The fossil record gives the order of arrival: the oldest

simple cells found so far are about 3.5 billion years old, and the oldest complex ones about 1.7 billion, so simple cells came first by almost two billion years.

The nucleus holds nearly all of a cell's genes, and the numbers are hard to picture. Each human cell holds roughly two meters of DNA, coiled up tight, and the nucleus that holds it is only about six to ten micrometers across. That is a ratio of 200,000 to one or more. Blow the nucleus up to a ball about 10 centimeters wide, about the size of a grapefruit, and the DNA would be a thread roughly 20 kilometers long. Outside, ribosomes read copies of the instructions and link amino acids into proteins. The nucleus keeps the archive, and the ribosome is the printing press.

The mitochondrion uses oxygen to make ATP, the molecule a cell uses everywhere as a source of chemical energy. Its inner membrane is folded into ridges called cristae, which give it more surface for the work. Yet it is stranger than a power plant. It has its own DNA, which resembles bacterial DNA, and its own ribosomes, which closely resemble bacterial ones rather than the cell's own. That has led to general acceptance of a startling idea. The ancestors of mitochondria were free-living bacteria that joined a larger cell long ago, for good. A rival account holds that mitochondria split off from the cell's own DNA, but the bacterial account is the more widely accepted.

Lynn Margulis argued that mitochondria and chloroplasts had once been independent bacteria, living on their own before they moved inside bigger cells, and for about a decade her theory was largely ignored. Her 1967 paper on the idea was rejected by about fifteen journals. In 1978 Robert Schwartz and Margaret Dayhoff experimentally demonstrated the descent of mitochondria from bacteria and of chloroplasts from cyanobacteria. The idea became widely accepted in the early 1980s, after the genes of mitochondria and chloroplasts were found to differ from the cell's own DNA. Chloroplasts, which capture sunlight, are thought to come from an ancient bacterium that an early cell swallowed.

Cells span a startling range of sizes. They vary from about one micrometer to hundreds of micrometers across. Then there is the neuron. The longest axon of a human motor neuron can be over a meter long, running from the base of the spine to the toes. So a single cell can be about a million times longer than a small bacterium is wide. A micrometer is a millionth of a meter, so you would need a million of those bacteria in a row to match one axon. Most neurons in the cerebral cortex form before birth and are not replaced, though how much new growth happens in adults is disputed.

How many cells are there in you? Until 2016, the usual answer rested on a ratio that had been repeated far more often than it had been checked. A new estimate for a 70 kilogram reference man says about 30 trillion human cells and about 38 trillion bacteria. So the long-repeated claim that microbes outnumber your own cells ten to one was wrong. The authors begin by noting that published numbers for cells in the body differ by orders of magnitude and are very

seldom backed by any measurement or calculation. Even a body's cell count, it turns out, is science still being done.

Even the textbook definition leaks. A mature red blood cell has thrown away its nucleus and its other parts to make room for hemoglobin, and it cannot divide. It lasts roughly 100 to 120 days, and yet by count it is most of the cells in a human body. Nobody doubts that it is a cell, though it spends its whole life carrying oxygen and little else. Most cells can copy themselves and make proteins, but highly specialized types such as red blood cells and egg and sperm cells are the exceptions. A definition built on those abilities describes the usual case, and it fails for the cells we count most.

The history of the word is a history of corrections. In 1665 the cell was a wall. By 1676 it could hold a living creature, by 1855 a unit with a parent, and now a factory with bacteria-descended engines inside. Each picture was useful, and each one left something out. The numbers kept changing as well, from no count at all to 30 trillion human cells and, in the same body, about 38 trillion bacteria. Hooke's slice of cork turned out to hold a handful of walls and an enormous question. Which of today's neat definitions will turn out, like his, to be the walls and not the room?

Questions

1. What had Hooke really seen in the cork?

A. Living bacteria
B. The empty walls of plant tissue
C. A whole nucleus

2. Why did Leeuwenhoek conclude that the tiny creatures he saw were alive?

A. They were red
B. They moved
C. They glowed under his lens

3. What evidence points to mitochondria having once been bacteria?

A. They are always green
B. They live outside cells
C. They have their own bacteria-like DNA and ribosomes

4. What does the essay mean by calling a cell "a standing disagreement with its surroundings"?

A. Cells fight with their neighbors
B. A cell keeps its inside different from its outside, which takes constant work
C. Cells cannot agree on a shape

5. Why does the author say the definition of a cell "leaks"?

A. Some cells, such as red blood cells, cannot replicate

B. Cells do not have membranes

C. Nobody has ever seen a cell

Words to know

nucleus: cell's gene room

ribosome: protein builder

mitochondrion: cell's power plant

chloroplast: sunlight catcher

hemoglobin: oxygen carrier

cytoplasm: cell's inner soup

Answer key: Rooms Within Rooms

1. B. The empty walls of plant tissue
2. B. They moved
3. C. They have their own bacteria-like DNA and ribosomes
4. B. A cell keeps its inside different from its outside, which takes constant work
5. A. Some cells, such as red blood cells, cannot replicate