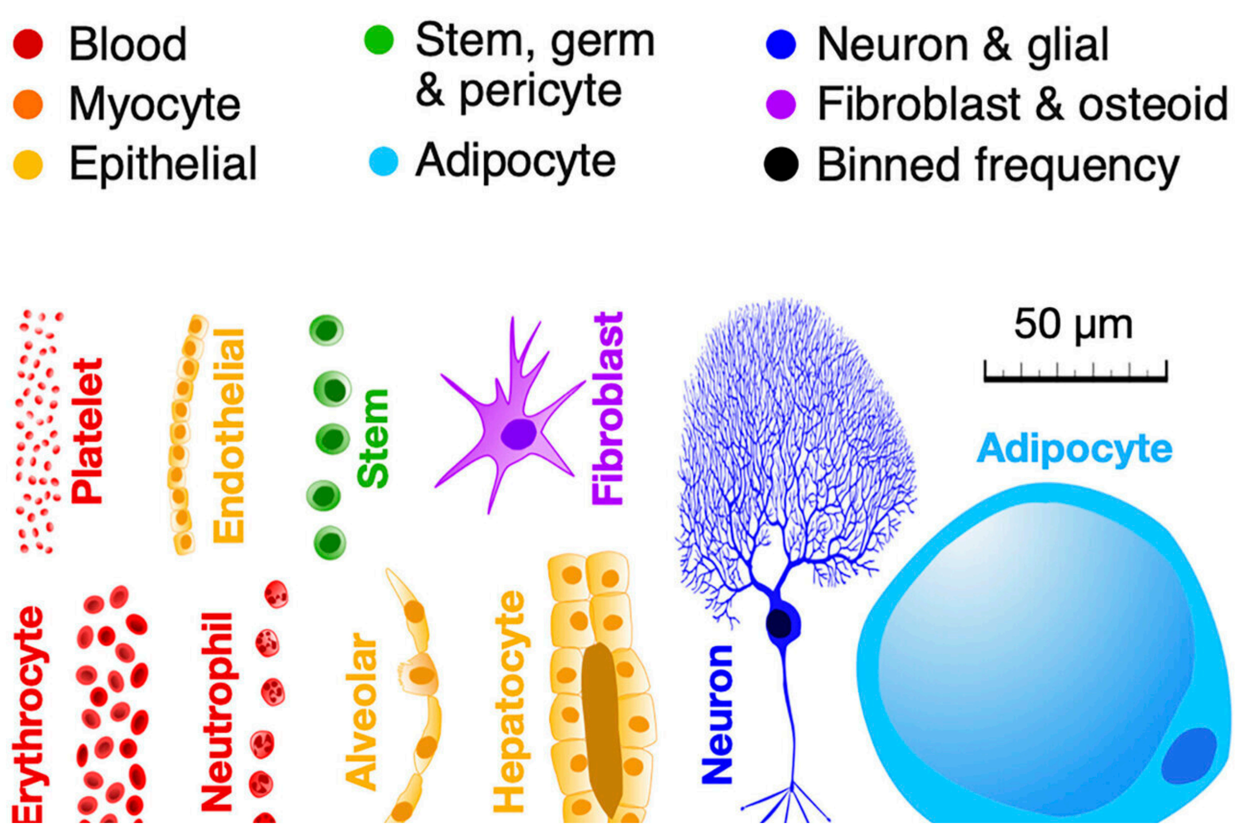
Common statistical principles of scaling found in nature now seen in human cells

September 20 2023, by Justin Jackson



Human cell size and count are nearly inversely related. Data and regression are shown for a 70-kg reference male, though very similar patterns are found for female and child. The total number of cells in each of 26 logarithmic size classes is regressed against cell mass (g), giving a slope near −0.97, as shown by the black line fit to black circles. The yellow band shows the 95% CI (±0.1), while the dashed gray line shows a reference slope of −1. Small colored circles (n = 700) include 401 distinct cell types, in addition to single cell types that have large variation in size (e.g., adipocytes, neurons and myocytes). These points represent mean cell-size values for each cell group, and are aggregated over their size range into size class sums represented by black points (Materials and Methods). In some cases, cells with broad size distributions (e.g., adipocytes; light blue) have counts of mean sizes that are higher than the size class sum (black points), since the counts of actual sizes are spread lognormally over multiple size classes. The open gray circle (Top Left) is the bacterial microbiome. Credit: *Proceedings of the National Academy of Sciences* (2023). DOI: 10.1073/pnas.2303077120

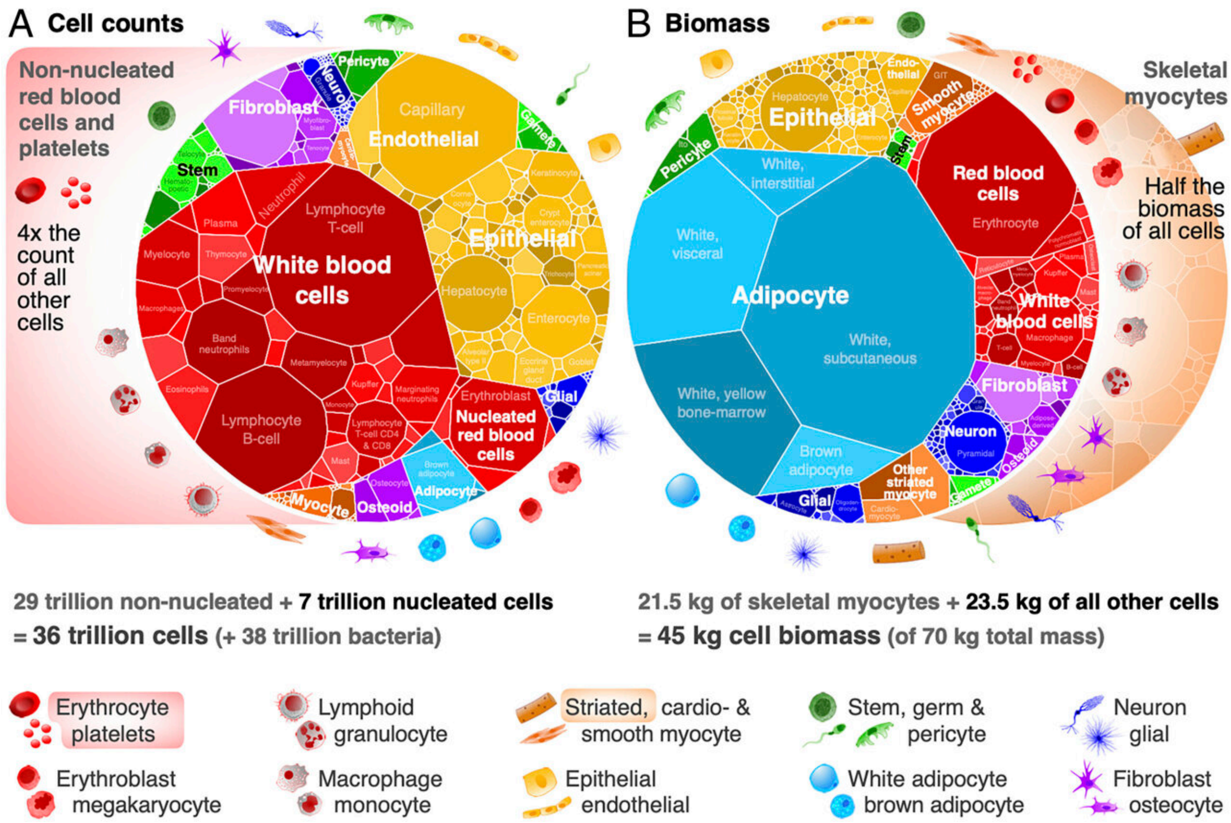
Research led by the Department of Earth and Planetary Sciences, McGill University, Canada, has found that human cells seem to follow a homeostasis pattern of cell size and count across the entire organism.

In a paper, "The human cell count and size distribution," published in *Proceedings of the National Academy of Sciences*, the researchers unveil a mystery of mathematical symmetry across human cell tissue types, hinting at an unknown developmental mechanism that seems to follow a structured course commonly seen in nature.

The intriguing discovery is of an inverse relationship between cell size and count. As cell size increases, the cell count decreases and vice versa so that cells within a given logarithmic size class contribute equally to the body's total cellular biomass. The study reveals that this relationship holds across various cell types and size classes, suggesting a trade-off between these variables.

Cell size and count are essential factors in the human body's growth and function. Until now, no study has examined the relationship between cell size and count across the entire human organism. The team compiled a comprehensive dataset of cell size and count across major cell types, drawing from over 1,500 published sources.

The data reveals estimated total body cell counts of approximately 36 trillion cells for a male, 28 trillion cells in females, and 17 trillion cells in a child of ten years old. The distribution of cell biomass in the human body is dominated by muscle and fat cells, while red blood cells, platelets, and white blood cells largely influence cell counts. Each cell type typically maintains a characteristic size range, which is uniform throughout an individual's development, and the same holds across mammalian species.



Contrasting cell count and biomass distributions by cell type. Voronoi tree maps for all 400 investigated cell types of the reference male anatomical model (area represents relative cell number or biomass). (*A*) Cell counts are dominated by red blood cells and platelets, which are removed from the cell count tree map. Even after removing nonnucleated blood cells (≈29 trillion), white blood cells (≈3.4 trillion) still dominate the ≈7 trillion nucleated cell count, with 98% of white blood cells as tissue resident, 1% circulating and 1% intravascular marginating.

(*B*) Cell biomass is dominated by skeletal myocytes, comprising about half of all 45 kg of cell biomass in the body, even though they make up

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