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How we grow: The biology and pathology of how we, our animal relatives, our tissues and organs, and our cancers, grow well and badly

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Growth is the most essential quality of multicellular organization. The creation of animal life, that is, the creation of the integrated biological entity that is the aggregate result of the mitotic offspring of a single founder cell, often initiated by fertilization, was made possible by the limitation of cell division to a fraction of cells, g, such that g≈1 at fertilization, declining towards zero as adult size is reached. In precisely what form this decline occurs, and how animals achieve such growth, have been unanswered questions for more than a century. In order to examine the role of cell division in growth, we assembled data on the number of cells in the organism, N, by age, t, in days from fertilization until adulthood, for 11 organisms - humans, frogs, nematodes, chickens, cows, geese, mice, quail, rats, turkeys, and clams - and calculated the value of the growth fraction, g as size, N, increases. These measurements revealed that the rate of growth starts out as exponential, and then the growth fraction transitions to a rapid decline, which is well captured by the expression g=A^N^B, where parameters A and B characterize each organism. We also identified a possible mechanism by which the molecules that control cell division can lead to such growth, as the unobvious consequence of the discrete nature of such molecules. These findings suggests a general growth law for capturing the large-scale feature of growth from the fertilized egg to adulthood, where the rate of growth= [ln(2)/C]*N*A^N^B, where C is the cell cycle time. This new method for charactering growth, and the new growth equation found by this method, have a variety of practical applications, from developing methods for optimization of the harvesting of clams, to assessing the growth of human fetuses and children, to understanding the growth of cancer, and to creating improved computer simulations models for determining the optimal ways to use cancer screening to lower the cancer death rate.

Biography

James Michaelson is the Director of the Laboratory of Quantitative Medicine, Member of the Departments of Pathology and Surgery at the Massachusetts General Hospital and Associate Professor in Harvard University. His research concerns: The assembly of very large databases on patients; the development of improved mathematical methods for predicting cancer outcome; the analysis of patient outcome and cost; the analysis of cancer screening; the mathematics of growth; the mathematics of metastasis; the use of modern computer speech and telephony to design systems that improve patient compliance and the development of advanced method for imaging cancer specimens.

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